

Dust Properties in H II Regions in M 33

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ABSTRACT

Context. The infrared emission (IR) of the interstellar dust has been claimed to be a tracer of the star formation rate. However, the conversion of the IR emission into star formation rate can be strongly dependent on the physical properties of the dust, which are affected by the environmental conditions where the dust is embedded.

Aims. We study here the dust properties of a set of H II regions in the Local Group Galaxy M 33 presenting different spatial configurations between the stars, gas and dust to understand the dust evolution under different environments.

Methods. We model the SED of each region using the DustEM tool and obtain the mass relative to hydrogen for Very Small Grains (Y_{VSG}), Polycyclic Aromatic Hydrocarbons (Y_{PAH}) and Big Grains (Y_{BG}). We furthermore perform a pixel-by-pixel SED modelling and derive maps of relative mass of each grain type for the whole surface of the two most luminous H II regions in M 33, NGC 604 and NGC 595.

Results. The relative mass of the VSGs ($Y_{\text{VSG}}/Y_{\text{TOTAL}}$) changes with the morphology of the region: $Y_{\text{VSG}}/Y_{\text{TOTAL}}$ is a factor of ~ 1.7 higher for H II regions classified as *filled* and *mixed* than for regions presenting a shell structure. The enhancement of VSGs within NGC 604 and NGC 595 is correlated to expansive gas structures with velocities $\geq 50 \text{ km s}^{-1}$. The gas-to-dust ratio derived for the H II regions in our sample exhibits two regimes related to the H I–H₂ transition of the ISM. Regions corresponding to the H I diffuse regime present a gas-to-dust ratio compatible with the expected value if we assume that the gas-to-dust ratio scales linearly with metallicity, while regions corresponding to a H₂ molecular phase present a flatter dust-gas surface density distribution.

Conclusions. The fraction of VSGs can be affected by the conditions of the interstellar environment: strong shocks of $\sim 50\text{--}90 \text{ km s}^{-1}$ existing in the interior of the most luminous H II regions can lead to fragmentation of BGs into smaller ones, while the more evolved shell and clear shell objects provide a more quiescent environment where reformation of dust BG grains might occur. The gas-to-dust variations found in this analysis might imply that grain coagulation and/or gas-phase metals incorporation to the dust mass is occurring in the interior of the H II regions in M 33.

Key words. galaxies: individual: M 33 – galaxies: ISM – infrared: ISM – ISM: H II regions, bubbles, dust, extinction.

1. Introduction

The presence of interstellar dust in star-forming regions is supported by the observed mid-infrared (MIR) and far-infrared (FIR) emission in star-forming regions. In the Milky Way several studies have shown that dust is ubiquitous in star-forming regions and at the same time exhibits a wide range of properties (see e.g. Churchwell et al. 2009). Within a single galaxy the properties of dust emission change very strongly, from cold dust in the diffuse ISM to warm dust processed by the intense radiation field within the star-forming regions (Xilouris et al. 2012). Since the pioneer study of Calzetti et al. (2005) where a correlation between the $24 \mu\text{m}$ emission and the emission of the ionised gas was observed for star-forming regions in NGC 5194, several studies have probed the correlation between the IR dust emission

and the emission of ionised gas in many galaxies with different properties (see e.g. Calzetti et al. 2007). Dust appears to survive in the interior of the star-forming regions and its infrared emission is spatially correlated with the location of the newly formed stars.

Interstellar dust can also be affected by the environment in which it is located and thus exhibits different physical properties depending on the characteristics of the interstellar medium (ISM) that surrounds it. Dust does not remain with the same physical properties during its lifetime, as dust particles interact with the medium where they are embedded (see Jones 2004). Dust is a key for understanding star formation, its production/destruction mechanisms and how they are linked to star formation are not yet completely clear. This hampers our ability to

trace accurately star formation or the gas reservoir, as this requires assumptions on the dust properties and size distribution.

There are several mechanisms affecting the evolution of the dust, some of them leading to a change in the physical properties and others to the destruction of a particular dust species (see Jones 2004, for a review). (i) Photon-Grain interactions: high-energy UV-visible photons are absorbed and scattered leading to grain heating and subsequent thermal emission, (ii) Atom/Ion-Grain interactions: at high gas temperature, impinging atoms or ions can erode the grain and lead to sputtering of atoms from the grain. This mechanism depends on the relative gas-grain velocities. When the gas-grain velocity is due to the motion of the grain relative to the gas, as in a SN shock wave, the process is called non-thermal sputtering; and if the relative gas-grain velocity is due to the thermal velocity of the gas ions (e.g. in a hot gas at more than 10^5 K as it occurs in the hot post-shock gas in a SN bubble), the process is called thermal-sputtering. In general, sputtering affects the grain surfaces but cannot disrupt the grain cores unless complete grain destructions occurs. (iii) Low-energy grain-grain collisions lead to grain coagulation, increasing the mean grain size, while at higher energies grain fragmentation/disruption can occur. Shattering in grain-grain collisions preserves the total grain mass but alters the grain size distribution.

Jones et al. (1996) (see also Bocchio et al. 2014, for dust processing with the new dust model from Jones et al. (2013)) studied the effects of grain shattering in shocks through grain-grain collisions which produces fragmentation of all, or part of, a grain into smaller but distinct sub-grains. The result is a transfer of mass from large (~ 200 Å) grains into smaller (~ 60 Å) ones, which leads to a change of the grain size distribution, being the mass percentage of small grains formed by shattering up to 40% higher for the case of grains with radii greater than 50 Å.

Despite the theoretical studies regarding the dust evolution within different environments, little has been done from the observational point of view. Recently, Paradis et al. (2011) and Stephens et al. (2014) (see also Compiègne et al. 2008) have presented evidence of dust evolution for some H II regions in the Large Magellanic Cloud (LMC). Also, Bernard et al. (2008) found a $70\mu\text{m}$ excess in the SED of the LMC with respect to the Milky Way and proposed the production of a large fraction of very small grains (VSGs) via erosion of larger grains as the most plausible explanation for this excess.

Although these studies show evidence of a change in the dust size distribution of individual H II regions, a systematic study of a large H II region sample covering a wide range of physical properties is needed in order to infer firm conclusions about the evolution of dust in different environments. Relaño et al. (2013) (hereafter Paper I) presented observational SEDs of a set of H II regions in the nearby (840 kpc, Freedman et al. 1991) spiral galaxy M 33 covering a wavelength range from the UV (GALEX) to the FIR (Herschel). Using the H α emission distribution of each object, the regions of the sample were classified as *filled*, *mixed*, *shell* and *clear shell* objects (fig. 2 in Paper I, shows examples of each type). Each morphological classification might well represent an evolutionary stage of the H II region from ages of a few Myr for *filled* and *mixed* regions, where gas (and dust) is co-spatial with the stellar cluster, to 5-10 Myr for *shells* and *clear shells*, where the massive stellar winds and supernovae (SN) have created holes and shell structures around the stellar cluster (Whitmore et al. 2011). A different star-gas-dust spatial configuration (see fig. 3 in Verley et al. 2010) is also expected for each morphological type. Paper I studied trends in

the observed SEDs with the morphology of the region and found that the FIR SED peak of regions with *shell* morphology seems to be located towards longer wavelengths, implying that the dust is cooler for this type of objects. Assuming a characteristic environment for each H II region type (the star-gas-dust spatial configuration is different in *filled* compact regions and shell-like objects), we would expect an evolution of the physical properties of the dust in each morphological type.

Dust evolution processes can be studied through the variation of the dust size distribution and, in particular, with the ratio of the abundance of small to large grains (Compiègne et al. 2008). Therefore, we present a study of the relative abundance of small to large grains for the H II regions in M 33 and analyse the results in terms of the region morphology. We estimate the abundances of the different grain types by modelling the observed SEDs with the dust emission tool DustEM (Compiègne et al. 2011). DustEM allows us to obtain the mass abundance relative to hydrogen of each dust grain population included in the model (several dust models can be considered by the software tool), as well as the intensity of the interstellar radiation field (ISRF) heating the dust.

The paper is organised as follows. In Sect. 2 we present the observations and describe in detail the new data set that complements the SEDs already published in Paper I. In Sect. 3 we describe how the observed SEDs were derived and how the dust modelling is performed. The results are described in Sect. 4. A detailed analysis of the two most luminous H II regions in M 33, NGC 604 and NGC 595, is presented in Sect. 5. Finally, in Sect. 6 we summarise the main conclusions of this paper.

2. The data

The observed SEDs of the H II regions are built up using data from the FUV to FIR wavelength range. We use the same UV, H α , *Spitzer* data presented in Paper I, therefore we refer the reader to this paper for further description of these particular data. Here, we describe the new data set included in this study.

2.1. Herschel data

In Paper I we used $100\mu\text{m}$ and $160\mu\text{m}$ PACS and $250\mu\text{m}$ SPIRE data. For this paper, we use the latest version of $100\mu\text{m}$ PACS data reprocessed with Scanamorphos v16 (Roussel 2013) as described in Boquien et al. (2011) with a resolution of $7''.7$, and the new observed $70\mu\text{m}$ and $160\mu\text{m}$ PACS data, obtained in a follow-up open time cycle 2 programme of *Herschel* (Boquien et al. 2015) with a resolution of $5''.5$ and $11''.2$. We take into account the difference of the astrometry into account in the $100\mu\text{m}$ image already reported in Boquien et al. (2015) and change the coordinates of the image accordingly. The field of view of the new $70\mu\text{m}$ and $160\mu\text{m}$ PACS data is slightly smaller than the field of view of the data set in Paper I, and 4 regions of the original sample in Paper I are missing in the new PACS images. Therefore, the $70\mu\text{m}$ and $160\mu\text{m}$ fluxes of these regions were discarded from the analysis presented here.

The SPIRE and the $100\mu\text{m}$ PACS data were taken in the framework of the HerM33es open time key project (Kramer et al. 2010). The $250\mu\text{m}$ SPIRE image with a resolution of $21''.2$ was obtained using the new version 10.3.0 of the *Herschel* Data Processing System (HIPE, Ott 2010, 2011). For a description of the data reduction the reader is referred to Xilouris et al. (2012). The calibration uncertainties are 5% for the PACS images and 15% for the $250\mu\text{m}$ SPIRE image. Due to the low spatial resolution we did not use $350\mu\text{m}$ and $500\mu\text{m}$ SPIRE data.

2.2. WISE data

The *Wide-field Infrared Survey Explorer* (WISE) (Wright et al. 2010) observed M 33 in four photometric bands: $3.4\mu\text{m}$ (W1), $4.6\mu\text{m}$ (W2), $12\mu\text{m}$ (W3), and $22\mu\text{m}$ (W4) with spatial resolutions of $6''.1$, $6''.4$, $6''.5$, and $12''.0$, respectively. We use the Image Mosaic Service *Montage*¹ to obtain the final mosaic image of M 33 in each band. After subtracting the global background, the WISE maps were converted from digital numbers to Jy using the photometric zero points given in table 1 of the *Explanatory Supplement to the WISE All-Sky Data Release Products*². We follow Jarrett et al. (2013) and apply the corrections recommended by them for extended source photometry. First, we apply an aperture correction that accounts for the Point Spread Function (PSF) profile fitting used in the WISE absolute photometric calibration. The corrections are 0.034, 0.041, -0.030 and 0.029 mag for the W1, W2, W3 and W4 bands, respectively. The second correction is a colour correction that we do not apply here, as it is already taken into account by the SED fitting process within the DustEM code (see Sect. 3.2). The third correction, related to a discrepancy in the calibration between the WISE photometric standard blue stars and red galaxies, only applies to the W4 image and accounts for a factor of 0.92. The calibration accuracy of the WISE maps are 2.4%, 2.8%, 4.5% and 5.7%, for W1, W2, W3 and W4 images (Jarrett et al. 2011).

2.3. LABOCA $870\mu\text{m}$ data

LABOCA (Large APEX BOlometer CAmera) is a multi-channel bolometer array for continuum observations (Siringo et al. 2009) installed at APEX³ (Atacama Pathfinder EXperiment) telescope covering a bandwidth of $\sim 150\mu\text{m}$ around the central wavelength of $870\mu\text{m}$. The FWHM of the PSF is $\sim 19''.2$ (Weiß et al. 2009), close to that of the $250\mu\text{m}$ SPIRE band. We refer the reader to Hermelo et al. (2016) for a description of the data reduction of the LABOCA observations of M 33. 10 H II regions of the original sample in Paper I are located close to the edge of the LABOCA field of view and thus we were not able to perform an accurate photometry for these objects. Therefore, their fluxes in this band were not considered in the analysis of the SEDs. The uncertainty in the calibration is $\sim 12\%$.

Observed LABOCA fluxes include emission from the CO rotational transition CO(3-2) at $870\mu\text{m}$ and from thermal free-free emission. Hermelo et al. (2016) estimate the CO(3-2) contribution to the total LABOCA flux of M 33 to be $\sim 7.6\%$. We adopt this value for the fluxes of the individual H II regions. The thermal emission is estimated from the analysis of Tabatabaei et al. (2007) at 3.6 cm. These authors obtained from multi-wavelength data, using two different methods, a thermal fraction of 76.4% and 99.2% for the observed 3.6 cm flux. Adopting the mean value of both methods and a spectral index of 0.1 we obtain a thermal contribution of 3% to the LABOCA observed flux. We take into account both CO(3-2) and thermal contributions and subtract them from the observed LABOCA fluxes for each object.

¹ <http://hachi.ipac.caltech.edu:8080/montage>

² http://wise2.ipac.caltech.edu/docs/release/allsky/expsup/sec2_3f.html

³ This publication is based on data acquired with the Atacama Pathfinder Experiment (APEX) under programme IDs 085.F-0045, 086.F-9301 and 089.C-0935. APEX is a collaboration between the Max-Planck-Institut für Radioastronomie, the European Southern Observatory, and the Onsala Space Observatory.

2.4. GISMO 2 mm data of NGC 604

The Goddard-IRAM Superconducting 2 Millimeter Observer (GISMO) continuum camera on the IRAM 30m telescope (Staguhn et al. 2006) works at a central frequency of 150 GHz, with $\Delta\nu/\nu=0.15$ (or a band-width of 22 GHz at 150 GHz). It comprises an array of 8×16 pixels separated by $14''$ on the sky, with a resolution of $17.5''$.

Observations of NGC 604 were conducted in several shifts, in April 2012, and April, October, and November 2013, during about 26 hours of total observing time by 181 on-the-fly scanning maps in total power of $10'\times 10'$ in size. Typical scanning speeds were $44''/\text{s}$. To correct for atmospheric transmission, the IRAM taumeter was used, which continuously measures the sky opacity at 225 GHz. The GISMO conversion factor, 29.3 counts/Jy, was derived from Mars, Uranus, and Neptune observations. The relative calibration uncertainty is estimated to be $\sim 10\%$ (see the reports on the GISMO performance⁴). To obtain the positions of the GISMO pixels on the sky and source gains, Mars was mapped covering the source within each pixel. The crush⁵ data processing software (vers. 2.16-3) (Kovacs 2008) was used with the options for faint emission. NGC 604 is detected with a total flux density of 64.4 mJy integrated over a $74.2''$ aperture radii. The peak flux density is 18 mJy/beam. The rms was measured to be 0.55 mJy/beam. The final map of NGC 604 is presented in Fig. 1.

The observed GISMO flux needs to be corrected for the thermal emission of the free electrons within the ionised gas. We use the results from Tabatabaei et al. (2007) at 3.6 cm to estimate this contribution as in Sect. 2.3. We obtain that 51% of the observed flux in GISMO corresponds to thermal emission. We subtract this contribution from the observed GISMO flux, both for the global and the pixel-by-pixel analysis presented in Sect. 5.

2.5. CO and HI data

We use here the $^{12}\text{CO}(J=2-1)$ (at 230.538 GHz) velocity integrated intensity map presented in Druard et al. (2014). The spatial resolution of the map is $12''$ with a pixel size of $3''$. The HI (21 cm) intensity map is presented in Gratier et al. (2010), it has a spatial resolution of $17''$ and a pixel size of $4.5''$. Details of data reduction are given in Druard et al. (2014) and Gratier et al. (2010), for CO and HI intensity maps, respectively.

3. Methodology

In this section we explain how the photometry was performed and describe the SED fitting procedure.

3.1. Photometry

We aim to model the SED of the set of H II regions studied in Paper I including the new PACS, WISE, and LABOCA data. Since we also use the new version of the SPIRE $250\mu\text{m}$ data, we smooth and register all the images from FUV to LABOCA, CO and HI to the resolution of the new version of the SPIRE $250\mu\text{m}$ image. The final data set has a spatial resolution (FWHM) of $21.2''$ (~ 86 pc) and a pixel size of $6''$ (~ 24 pc).

The total flux for each region is obtained using the IRAF task *phot* and the central coordinates and aperture radii defined

⁴ http://www.iram.es/IRAMES/mainWiki/\Continuum/GISMO/Main#Documentation_and_Publications

⁵ <http://www.submm.caltech.edu/~sharc/crush/>

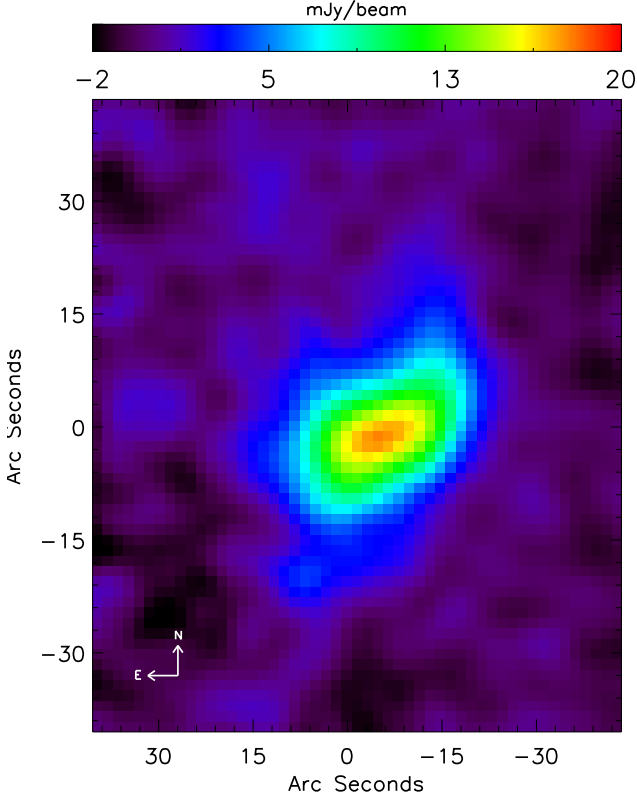


Fig. 1. 2 mm image of NGC 604 observed with the GISMO continuum camera. The final spatial resolution of the image is $21.0''$ to match the other data.

in table 1 of [Paper I](#). The photometric aperture radii range from ~ 50 pc for *filled* regions to ~ 250 pc for *clear shell* objects (see Fig. 4 in [Paper I](#)). The local background is defined and subtracted as it was done in [Paper I](#). Regions with absolute fluxes lower than their errors are assigned an upper limit of 3 times the estimated uncertainty in the flux. The negative fluxes showing absolute values higher than the corresponding errors are discarded from the study. The final fluxes for all the bands used in this paper, as well as FUV, NUV and $H\alpha$ fluxes, are given in Tables A.1 and A.2.

We compared the fluxes obtained here from the updated data set with the fluxes already published in [Paper I](#). For FUV, NUV, IRAC, and MIPS bands we find differences of $\leq 20\%$ mainly related to the subtraction of the local background (differences for the fluxes without subtracting the local background are $\sim 1\%$). The lower the flux of the region, the larger the difference, which shows that for some regions the uncertainties are dominated by the estimate of the local background.

For the PACS $100\mu\text{m}$ and $160\mu\text{m}$ images the differences in the fluxes are larger. The main reason is that there is a significant difference in the data reduction process of the last version (Scanamorphos v16) of these images, improving the drift removal ([Boquien et al. 2015](#)). This can affect the fluxes for the low luminosity H II regions in these bands (see Fig. B.1).

3.2. SED modelling

In order to study the properties of the dust in the sample of H II regions we fit the observed SEDs with the dust emission tool

DustEM ([Compiègne et al. 2011](#)). The code allows a combination of various grain types as input and gives the emissivity per hydrogen atom ($N_H = N_{H I} + 2N_{H_2}$) for each grain type based on the incident radiation field strength and the grain physics in the optically thin limit. The free parameters are the mass relative to hydrogen of each dust population (Y_i), the intensity of a NIR continuum modelled using a black body with a temperature of 1000 K and the ISRF parameter G_0 , which is the scale factor to the solar neighbourhood ISRF given in [Mathis et al. \(1983\)](#). The origin of the 1000 K black body emission is uncertain. It was observed by [Lu et al. \(2003\)](#) with ISO/ISOPHOT in a sample of 45 normal star-forming galaxies, it has also been observed in the spectra of reflection nebulae ([Sellgren et al. 1983](#)) and in the diffuse cirrus emission of the Milky Way ([Flagey et al. 2006](#)). We were not able to fit the SEDs of our regions without including this component, therefore we have included it and obtained the scale factor as an output parameter. Given an observed SED and the associated uncertainties, DustEM performs the SED fitting using the MPFIT IDL minimisation routine ([Markwardt 2009](#)), based on the Levenberg-Marquardt minimisation method. In the process DustEM predicts the SED values that would be observed by the astronomical instruments taking into account the colour corrections for wide filters and the flux conventions used by the instruments.

DustEM can handle an arbitrary number of grain types and size distributions. We adopt here the [Compiègne et al. \(2011\)](#) dust model (*Compiègne dust model*) which includes three dust components: Polycyclic Aromatic Hydrocarbons (PAHs) with radii $r \lesssim 10 \text{ \AA}$, hydrogenated amorphous carbonaceous grains (amC) and amorphous silicates (aSil) with radii $r \gtrsim 100 \text{ \AA}$. The population of amorphous carbon dust has been divided into small (SamC, $r \sim 10 - 100 \text{ \AA}$) and large (LamC, $r \gtrsim 100 \text{ \AA}$) grains. Besides, the model differentiates between ionised and neutral PAHs. We define $Y_{VSG} = Y_{\text{SamC}}$ and $Y_{BG} = Y_{\text{LamC}} + Y_{\text{aSil}}$, in a similar way as it was done in [Flagey et al. \(2011\)](#). In the fitting process we keep the ratio between the aSil and LamC grains at the constant value given by the model, 5.38, in order to have an acceptable ratio between observational data points and input parameters. We compare the results of this dust model with the classical one proposed by [Desert et al. \(1990\)](#) (hereafter the *Desert dust model*), which consists of three dust grain types: PAHs, VSGs of carbonaceous material, and big grains (BGs) of astronomical silicates. The comparison is presented in Appendix C. In general, the SED is also well fitted with the *Desert dust model*, except the $6-9\mu\text{m}$ wavelength range where the model underpredicts the observed emission. This shows that *Desert dust model* might not be reliable to constrain the PAH abundance.

3.3. Input radiation field

A more realistic ISRF for a typical H II region compared to the ISRF from [Mathis et al. \(1983\)](#) used as default in DustEM is that of a young star cluster. We have generated the spectrum of a young star cluster of 4 Myr using the online STARBURST99 application ([Leitherer et al. 1999](#)). We assume a Kroupa initial mass function ([Kroupa 2001](#)) and Geneva stellar tracks and obtain the spectrum for a fixed stellar mass of $10^4 M_\odot$ and 4 Myr age. The stellar mass and the age are consistent with those expected from the $H\alpha$ and FUV luminosities of the brightest H II regions in M 33 (see Fig. 5 of [Relaño & Kennicutt 2009](#)). In Fig. 2 we show the 4 Myr (continuous line) and *Mathis* (dashed

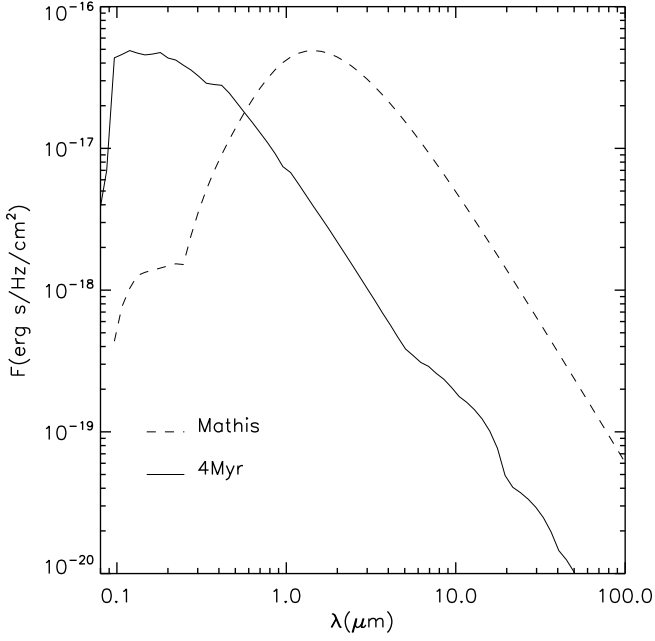


Fig. 2. Comparison of [Mathis et al. \(1983\)](#) ISRF (dashed line) and an ISRF of a 4 Myr star cluster (continuous line) (see text for details). Both ISRFs have been scaled to the same maximum intensity for a better comparison. The ISRF of a 4 Myr star cluster has a significant contribution in the UV part of the spectrum.

line) ISRFs. A 4 Myr ISRF is harder, having a significant contribution in the UV part of the spectrum.

The different shape of both ISRFs can influence the heating of the different types of dust grains. In Fig. 3 we show the results of the *DustEM* modelling for both ISRFs. Y_{VSG} does not change significantly when a different ISRF is assumed and Y_{BG} changes but the change is small and marginally located within the data dispersion. However, Y_{PAH} and the scale of the ISRF do change for *Mathis* and 4 Myr star cluster ISRFs. Y_{PAH} for the case of *Mathis* ISRF is ~ 3 times higher than Y_{PAH} when a 4 Myr star cluster ISRF is assumed and G_0 is a ~ 60 times higher than F_0 ⁶. The change in the scale parameter of the ISRF intensity is expected, as the 4 Myr star cluster ISRF is harder than the *Mathis* one. The reason why Y_{PAH} is higher for the *Mathis* ISRF is related to the shape of the ISRF. For the *Compiegne* dust model we expect, following the extinction curve given in [Compiegne et al. \(2011\)](#), that the PAHs will absorb more radiation in the UV part of the spectrum than in the optical. Thus, for a 4 Myr star cluster ISRF, which has a significant component in the UV wavelength range, the amount of PAH grains needed to explain the emission in the 3–10 μm range of the observed SED will be less than the one required for the *Mathis* ISRF. This shows that unless we are able to characterise the shape of the ISRF heating the dust within the regions we are not able to constrain completely the PAH abundance, there is a degeneracy between the PAH abundance and the scaling factor of the ISRF. However, we will be able to infer conclusions on the Y_{PAH} distribution within the region, as we will show in Sect. 5. In the following we will use a 4 Myr star cluster ISRF to model the SEDs of our H II region sample.

⁶ We define F_0 in the same way as G_0 but for the 4 Myr star cluster ISRF.

Table 1. Statistics of $Y_{\text{VSG}}/Y_{\text{TOTAL}}$, $Y_{\text{PAH}}/Y_{\text{TOTAL}}$, $Y_{\text{BG}}/Y_{\text{TOTAL}}$ for each morphological type of the H II regions in our sample. The error bars are the standard error of the mean.

Relative fractions	$Y_{\text{VSG}}/Y_{\text{TOTAL}}$	$Y_{\text{PAH}}/Y_{\text{TOTAL}}$	$Y_{\text{BG}}/Y_{\text{TOTAL}}$
<i>Compiegne</i> dust model			
<i>Filled</i>	0.04 ± 0.01	0.03 ± 0.01	0.93 ± 0.30
<i>Mixed</i>	0.045 ± 0.007	0.033 ± 0.005	0.92 ± 0.15
<i>Sh & Csh</i>	0.026 ± 0.004	0.033 ± 0.005	0.94 ± 0.16
<i>Desert</i> dust model			
<i>Filled</i>	0.09 ± 0.03	0.009 ± 0.003	0.91 ± 0.30
<i>Mixed</i>	0.10 ± 0.02	0.009 ± 0.002	0.89 ± 0.15
<i>Sh & Csh</i>	0.048 ± 0.008	0.012 ± 0.002	0.94 ± 0.16
Paradis et al. 2011			
Bright	0.20 ± 0.02	0.0091 ± 0.001	0.85 ± 0.01
Typical	0.074 ± 0.007	0.0095 ± 0.001	0.93 ± 0.06

4. Statistical analysis of H II regions

4.1. Results of the modelling

In Fig. 4 we show some examples of SEDs modelled with the *DustEM* code. PAH emission dominates the SED at shorter wavelengths (3–12 μm), while the emission of the VSGs has its maximum between 24 μm and 100 μm . At longer wavelengths ($\lambda > 100 \mu\text{m}$), the SED is dominated by the emission of the BGs. All the SEDs are fitted with residuals less than $\sim 50\%$ (see the bottom part of each figure).

In Fig. 5 we analyse the relative dust masses for each grain type for the best fit with a 4 Myr cluster ISRF. In the lower panels we plot the dust masses of the BGs and the PAHs relative to the total dust abundance for the best fit. BGs represent the highest fraction of dust mass in the regions ($\sim 90\%$, and varying within a small range) independently of the morphological type. The relative mass of the PAHs is $\lesssim 5\%$ except for three objects. [Draine & Li \(2007\)](#) found a value of 4.6% for the relative mass of the PAHs in the Milky Way and [Galliano et al. \(2008\)](#) showed that the PAH fraction varies significantly with the metallicity. The relative mass of the PAHs found here for most of our objects is consistent with the trend presented in Fig. 25 of [Galliano et al. \(2008\)](#) considering the metallicity of M 33⁷. There are no variations with morphology but we observe a trend of lower $Y_{\text{PAH}}/Y_{\text{TOTAL}}$ for regions with high FUV flux. We show here that the relative PAH mass abundance obtained using a 4 Myr cluster ISRF and the *Desert* dust model (see Fig. C.1) is lower than the one predicted by the *Compiegne* dust model.

The top-right panel of Fig. 5 shows the relative dust mass abundance for the VSGs. The most interesting feature in this plot is that the relative dust mass abundance for the VSGs changes with the morphology of the region: red stars, corresponding to *shells* and *clear shells* are located in the lower part of the figure, while green squares and blue dots, corresponding to *filled* and *mixed* regions respectively, tend to be in the top part of the distribution. The *shells* and *clear shells* do not present $Y_{\text{VSG}}/Y_{\text{TOTAL}}$ values higher than ~ 0.05 , while there is no *filled* nor *mixed* region with values of $Y_{\text{VSG}}/Y_{\text{TOTAL}}$ less than ~ 0.02 . This is clearly seen in the histogram at the right-hand side of the figure. In Table 1 we give the mean values of the relative abundance of

⁷ Since M 33 has a shallow metallicity gradient ([Bresolin 2011](#)), we use a mean value between the extreme cases of the radial gradient as the characteristic metallicity for M 33. Thus, for this study we assume $Z_{\text{M33}} \sim 0.5 Z_{\odot}$.

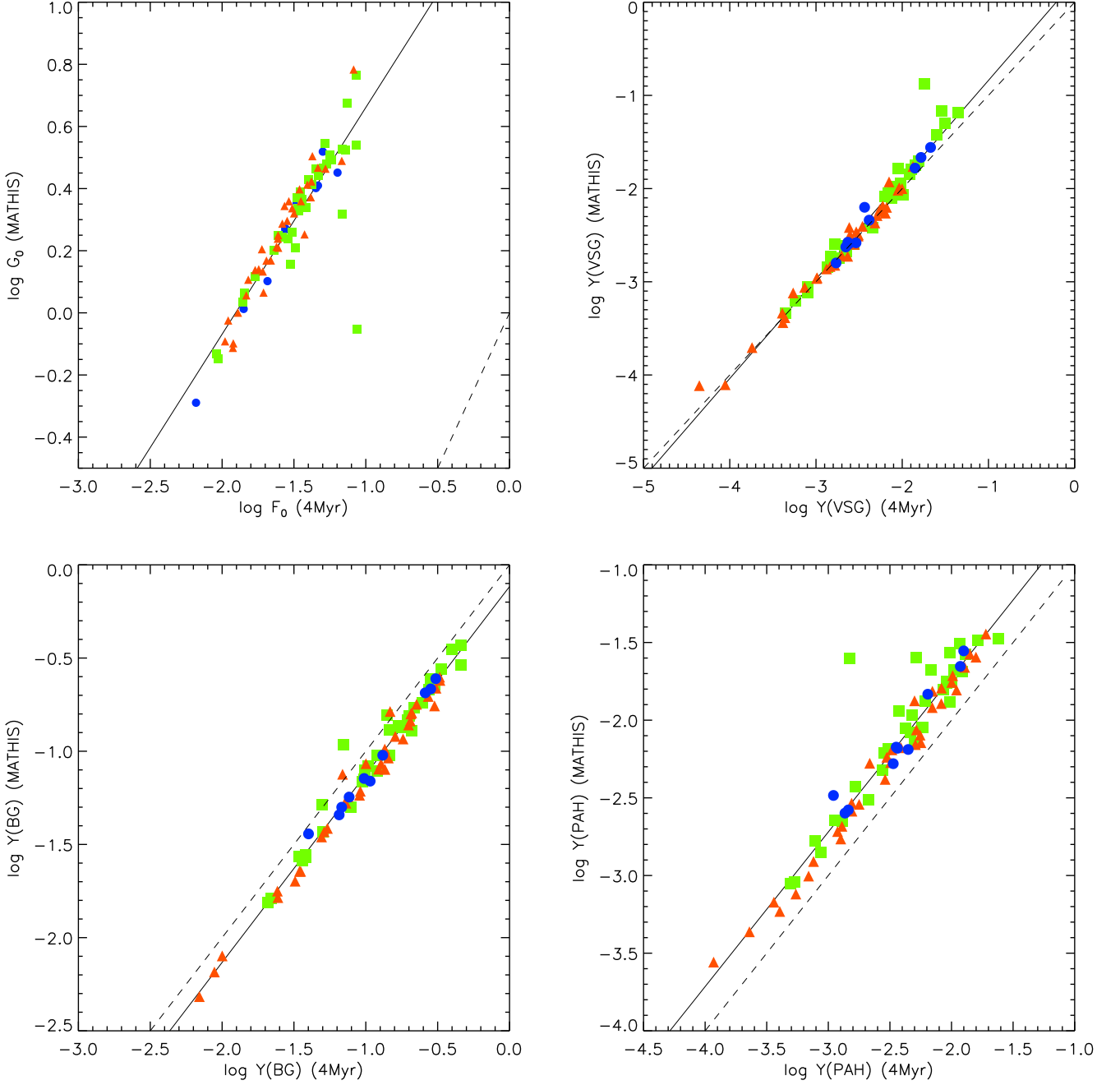


Fig. 3. Comparison of the DustEM output parameters for the H II regions in our sample using a 4 Myr star cluster ISRF and a *Mathis* ISRF. *Top-left*: scale factor of the ISRF intensity, *top-right*: Y_{VSG} , *bottom-left*: Y_{BG} , and *bottom-right*: Y_{PAH} . The continuous line corresponds to the linear fit to the data and the dashed line is the one-to-one relation. The colour code corresponds to the morphology of the region classified in [Paper I](#): blue circles are *filled* regions, green squares *mixed* ones, and red triangles *shells* or *clear shells*.

each grain type for each morphological classification. Regions classified as *shells* and *clear shells* have a factor of ~ 1.7 smaller fraction of dust mass in the form of VSGs than the *filled* and *mixed* regions, and the trend is the same using the *Desert* dust model (see Fig. C.2 and Table 1).

The trend shown here agrees with the results presented in other studies. [Paradis et al. \(2011\)](#) found, using the *Desert* dust model, an increase of the VSG relative abundance by a factor of 2–2.5 between *bright* and *typical* regions in the LMC (see Table 1 and Table 2 in [Paradis et al. \(2011\)](#)). *Bright* H II re-

gions in [Paradis et al. \(2011\)](#) would correspond to our *filled* and *mixed* regions, while the *shell* objects present lower H α surface brightness and can be included in the *typical* regions classification of [Paradis et al. \(2011\)](#). Regarding the PAHs, the values obtained here are slightly lower than those predicted by [Paradis et al. \(2011\)](#), but an agreement is found when we use the *Desert* dust model as in the [Paradis et al. \(2011\)](#) study (see Fig. C.2). Caution needs to be taken when using the *Desert* dust model, as this model is unable to fit the SED within the 6–9 μm wavelength range, under-predicting systematically the observed PAH

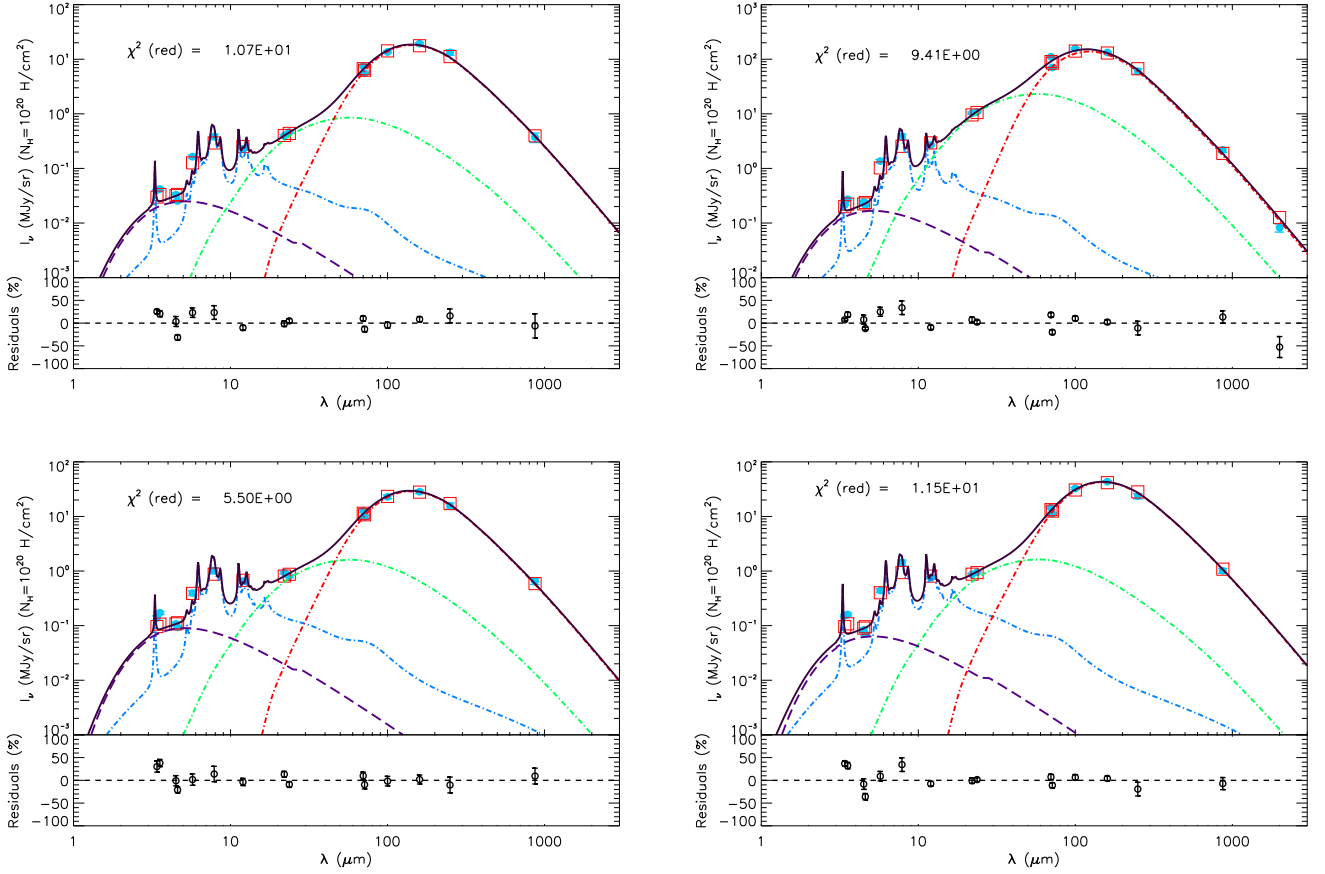


Fig. 4. Example of SED models for 4 regions of the sample catalogued as *filled* (top-left), *mixed* (top-right), *shell* (bottom-left), and *clear shell* (bottom-right). These regions correspond to reg. 5, reg. 98, reg. 45, and reg. 78 in Table B.1 in Paper I, respectively. Reg. 98 is the most luminous H II region in M 33, NGC 604. The best-fit SED (continuous black line) is obtained assuming a 4 Myr star cluster ISRF and *Compiegne* dust model. *Light blue points*: observed data with the errors, *red squares*: modelled broadband fluxes, *dashed-dot blue line*: total (ionised and neutral) PAH emission, *dashed-dot green line*: VSG (SamC) grain emission, *dashed red line*: BG (LamC and aSil grains) emission, and *dashed purple line*: NIR continuum.

emission (see Fig. C.1). We found no trend of relative PAH abundance with the morphology, while Paradis et al. (2011) found a factor of 0.96 between *bright* and *typical* regions in the LMC.

Stephens et al. (2014) analysed the IR emission in small sub-regions of two classical H II regions and two superbubbles in the LMC fitting the SEDs with DustEM code and using the *Desert* dust model. They found that the emission from VSGs increases at the inner locations of the two *classical* H II regions with respect to the values obtained at the edges of the region, while for the two superbubbles the enhancement is not observed. We are observing the same trend, the *filled* and *mixed* regions, which would be *classical* in Stephens et al. (2014) terminology, present higher fraction of VSGs than the *shells* and *clear shells*, corresponding to *superbubbles* in Stephens et al. (2014). The enhancement of the relative VSGs abundance in the center of the *classical* H II regions corresponds to the location where the ISRF is higher and where the massive stars are situated, as is calculated in Sect. 3.2 in Stephens et al. (2014). As we will discuss in Sect. 4.2, we expect an enhancement of VSGs at the position of strong shocks where the massive stars are located.

4.2. Morphology and dust properties

We show here that $Y_{\text{VSG}}/Y_{\text{TOTAL}}$ is higher for *filled* and *mixed* regions by a factor of ~ 1.7 . This trend allows us to understand the change in dust properties in different environments and to shed light on the dust evolution in the ISM. Jones et al. (1996) showed that dust grain-grain collisions, normally referred to *shattering*, lead to fragmentation of the entire grain, or part of it, into smaller distinct subgrains. Fig. 13 c of Jones et al. (1996) shows that large grains (radii $> 400 \text{ \AA}$) are disrupted by a single 100 km s^{-1} shock and that the grain mass is transferred to smaller grains. This *mass transfer* is seen in the resulting postshock grain size distribution (Fig. 17 in that paper). Moreover, the adoption of a different initial grain size spectrum does not greatly affect the final grain size distribution, as shown in Jones et al. (1996). A re-evaluation of the dust processing effects in shocks has been performed by Bocchio et al. (2014). These authors use the new dust model from Jones et al. (2013), which assumes only two grain types (hydrogenated amorphous carbon and large amorphous silicate grains), and found that both carbonaceous and silicate grains undergo more destruction than in the previous studies, being the silicates more resilient to shocks than the carbonaceous grains. Since we keep the ratio of the silicates and carbonaceous fixed in our models we are not able to test this further.

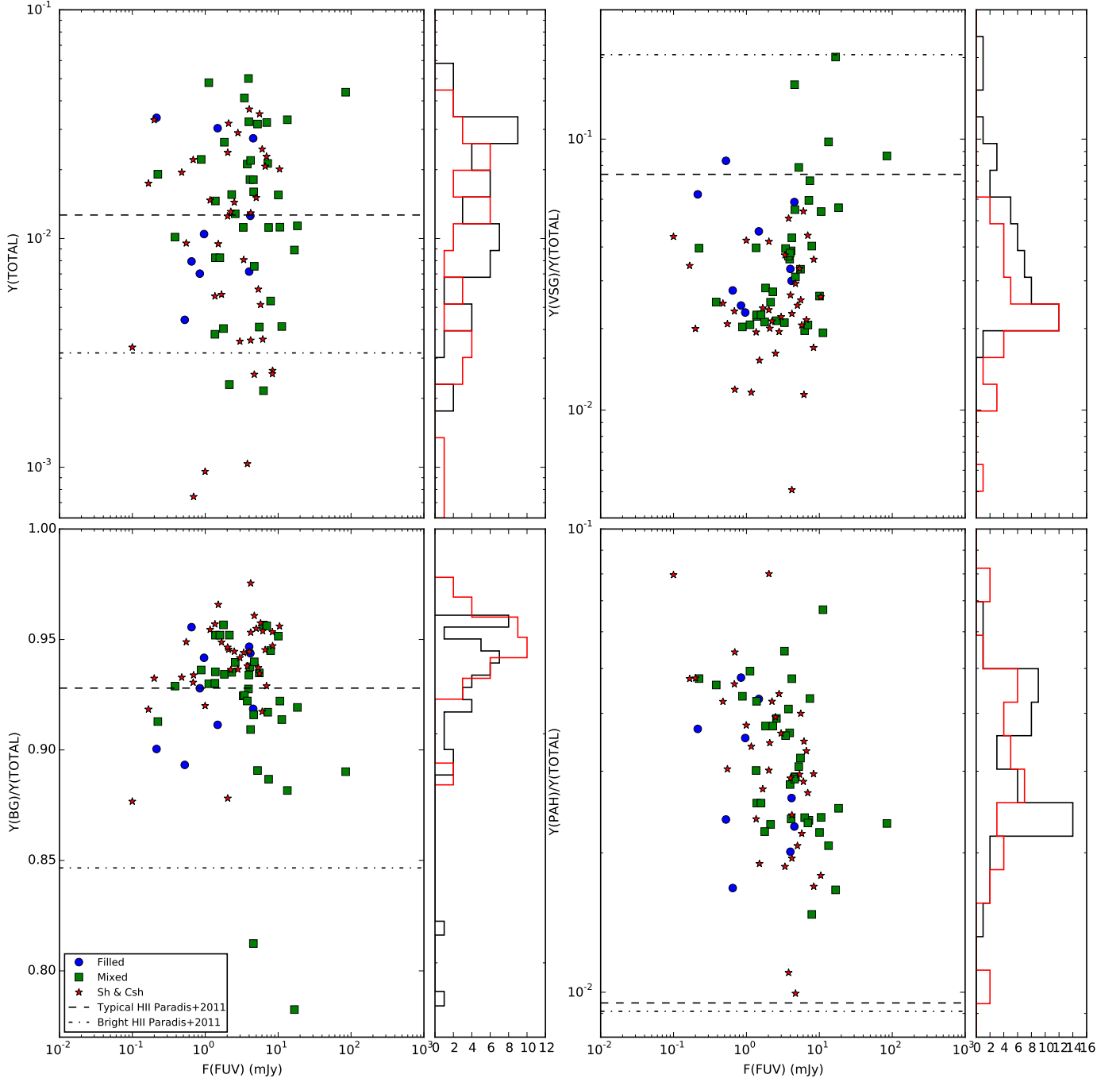


Fig. 5. Dust mass abundances obtained fitting the SED of each region using a 4 Myr ISRF and *Compiègne* dust model. Only fits with a $\chi^2_{\text{red}} < 20$ are taken into account. Blue circles are *filled* regions, green squares *mixed* ones, and red triangles *shells* or *clear shells*. Dashed and dashed-dotted lines correspond to the values obtained by Paradis et al. (2011) who separate between *typical* H II regions and regions being significantly brighter at H α : for *typical* (dashed line) and *bright* (dot-dashed line) H II regions in the LMC modelled assuming a 4 Myr star cluster ISRF and the *Desert* dust model. Mean values of the relative errors in the data presented in the figures are: 11%, 19%, 16% and 23% for top-left, top-right, bottom-left and bottom-right figures, respectively. Black histograms correspond to the filled and mixed regions and red ones to the shells or clear shells regions.

Our sample of H II regions classified as *filled* and *mixed* have central clusters rich in massive stars producing strong stellar winds and creating high-velocity ($\sim 50\text{--}90\text{ km s}^{-1}$, according to Relaño & Beckman 2005) expansive structures in their interiors. Therefore, for these regions a higher fraction of $Y_{\text{VSG}}/Y_{\text{TOTAL}}$ compared to more quiescent environments is expected according to the Jones et al. (1996) dust evolution model. *Shell* and

clear shell objects in our sample are in a more evolved and quiescent state. They have already swept up all the gas and dust in their close surroundings and they show prominent shell structures not only in H α but also in the longer wavelengths $250\text{ }\mu\text{m}$, $350\text{ }\mu\text{m}$, and $500\text{ }\mu\text{m}$ of SPIRE (see Fig. 3 of Verley et al. 2010). We expect these regions to have much lower shock velocities, as they are in a more evolutionary state, and therefore to present a

lower relative fraction of VSGs. This agrees with the results presented in Stephens et al. (2014), who showed that for the most evolved H II region in their sample, a superbubble named N70, $Y_{\text{VSG}}/Y_{\text{TOTAL}}$ is lower than for the less evolved H II regions in their sample. Another interpretation of the observed shell structures in the SPIRE bands could be the reformation of dust BGs via coagulation and accretion in dense clouds, as it has also been suggested by Jones et al. (1996). Stepnik et al. (2003) proposed grain-grain coagulation as the main mechanism to explain the deficit of the IRAS I(60 μm)/I(100 μm) flux ratio in the Taurus molecular complex compared to the diffuse ISM. The same region was studied by Ysard et al. (2013) using DustEM who found that the observed SED at different locations within the complex could be explained by changes in the optical properties of the grains. Paradis et al. (2009) found an increase of the FIR emissivity in molecular clouds along the Galactic plane with significantly colder dust and interpreted it as coagulation of dust grains into fractal aggregates. Although reformation of BGs is not excluded as a mechanism to explain the shell structures observed in the SPIRE bands, detailed estimations of the dust temperature of the BGs and the density of the ISM in these regions have to be obtained in order to check the viability of this phenomenon (Köhler et al. 2012). For example, Köhler et al. (2015) found that coagulation and accretion produce significant changes in the dust properties that can explain the observed SED variations between diffuse and denser regions.

4.3. Dust Temperature

In order to study the temperature of the dust for each H II region in our sample we make use of the equilibrium temperature provided by DustEM. The code provides, for each size, the equilibrium temperature of the LamC and aSil grains. For each grain type, we estimate the dust temperature as the mean value of the equilibrium temperature of all aSil grains with different sizes as in Ysard et al. (2013).⁸ We make use of the aSil grains because they are more abundant than LamC ones and the relative fraction between the two of them is kept constant in our fitting (see Sect. 3.2). In the left hand panel of Fig. 6 we show the distribution of the dust temperature for each morphological classification. We can see that there is only a slight trend for the distribution of the *shells* and *clear shells* to extend to lower temperatures, while the distribution for the *filled* and *mixed* regions is narrower, having a peak at ~ 18 K. We find a mean dust temperature of 18.3 ± 0.3 K and 17.8 ± 0.4 K for *filled* and *mixed* together, and *shell* type objects, respectively, which shows that there is no significant difference in the dust temperature for each classification.

We have also performed the same analysis using the classical definition of dust temperature from a modified blackbody (MBB) fitting. We use observational data in the 100-870 μm wavelength range, as the expected contribution of the stochastically heated grains in this wavelength range is negligible (for our set of H II regions the best fits give a mean contribution of $\sim 10\%$ of the VSGs to the 100 μm band). We adopt the simple approach to keep $\beta=2$ fixed and restrict the analysis to those fits with $\chi^2_{\text{red}} < 50$ ⁹ and having a model 70 μm flux below the ob-

served one. In total we end up with a set of 71 H II regions: 7 *filled*, 35 *mixed*, and 29 *shell* and *clear shell* objects. We find a mean dust temperature of 17.9 ± 0.6 K, and 15.5 ± 0.6 K for *filled* and *mixed*, and *shell* type objects, respectively.

We find that the equilibrium temperature for the BGs obtained with DustEM does not show any trend with morphology, while the dust temperature derived from the MBB shows differences that are slightly larger than 3σ . Based on these results, we cannot conclude that there is a statistically significant difference in the dust temperature distributions, but we find evidence from the MBB analysis that H II regions of *shell* type might have the lowest temperatures. This trend can be understood by the different star-to-dust geometries in the H II regions, as within *filled* and *mixed* regions the dust and gas is probably mixed and closer to the stars that heat the dust than in the *shells* and *clear shells* regions. Indeed, in the right panel of Fig. 6 we show the distribution of F_0 , a measure of the radiation field intensity (see Sect. 3.3), for both *filled* and *mixed*, and *shell* type regions, showing that *shell* objects are lacking the high values of F_0 that are present in some *filled* and *mixed* types. We find mean values of F_0 of 0.103 ± 0.008 , and 0.076 ± 0.006 for *filled* and *mixed*, and *shell* type objects, respectively.

We cannot rule out other mechanisms producing this slight difference in the dust temperature, as, e.g., a higher fraction of BGs in the *shell* regions that would imply cooler grains with respect to the *filled* and *mixed* objects. Indeed, we have already shown that the relative fraction of VSGs is lower in the *filled* and *mixed* regions (see Fig. 5). It is also worth to note that the emission at 250 μm relative to the TIR emission, an indicator of the dust temperature and/or the relative amount of BGs, presents higher values for *shell* regions than for *filled* and *mixed* objects (see Fig. 7): the mean value of the 250 μm /TIR ratio for *shell* regions is 0.73 ± 0.04 , while for *filled* and *mixed* objects is 0.53 ± 0.03 .

The trends shown here are consistent with previous results given in the literature. Paper I presented evidence of a far-IR peak shifted towards longer wavelengths in the SED of H II regions classified as *shell* and *clear shell* objects, which points to a colder dust in this type of objects. Verley et al. (2010) show examples of *filled* and *clear shell* regions where the dust emission distribution observed in different bands of *Spitzer* and *Herschel* differs from band to band. *Filled* regions tend to show emission in all IR bands, while *clear shell* objects do not show any emission at 24 μm and the emission in the SPIRE bands is delineating the shell structure of the region. The authors suggest an evolutionary scenario where the dust is affected by the expansion of the gas within the region. The *filled* regions would be younger. The stellar winds would have not been able to create a cavity yet, therefore the dust and ionised gas are mixed within the region. They present emission at 24 μm inside the region indicating that the dust is warm for these objects. The *clear shell* objects, however, would be more evolved. The expanding structure would have been created and the dust would have been swept together with the ionised gas. The lack of emission at 24 μm and the presence of SPIRE emission at the shells shows that the dust is cooler for these objects.

4.4. Gas-to-dust mass ratio

Using the available HI and CO data we are able to derive the gas mass within the aperture of each H II region in the sample. The DustEM fits provide us the dust mass for each region and therefore we can obtain the gas-to-dust mass ratio in our sample. The molecular mass is obtained using the $^{12}\text{CO}(J=2-1)$ and

⁸ Other authors use the equilibrium temperature of the most populated dust grain (Flagey et al. 2011). We have tested that the conclusions of this section do not change using this other definition of dust temperature.

⁹ χ^2_{red} is defined as χ^2/n , where n is the number of degrees of freedom and $\chi^2 = \sum (F_{\text{obs}} - F_{\text{mod}})^2 / \sigma^2$.

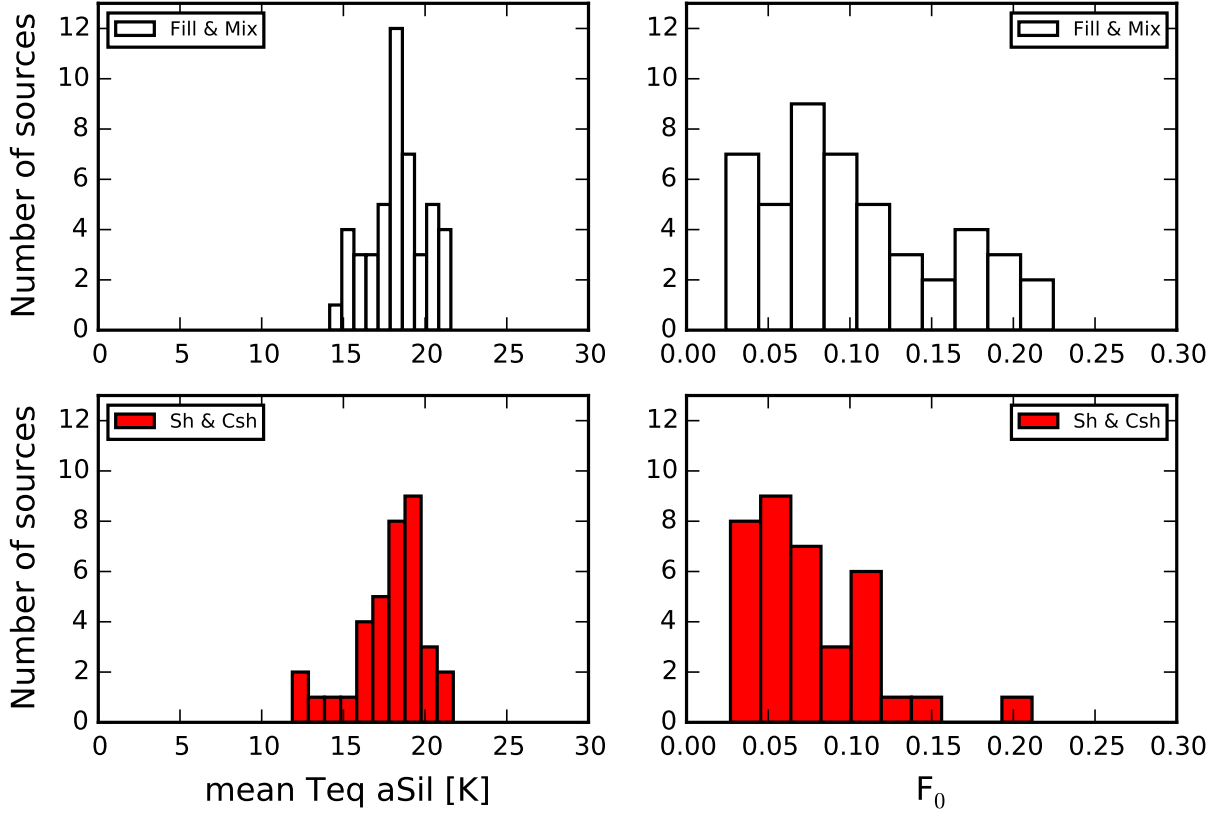


Fig. 6. Dust temperature (left) and F_0 (right) distributions for *filled* and *mixed* together, and *shell* morphologies. The dust temperature is defined as the mean of the equilibrium temperature of all the aSil grains with different sizes.

HI intensity maps presented in [Druard et al. \(2014\)](#) and [Gratier et al. \(2010\)](#), respectively. The data were smoothed and registered to the SPIRE $250\,\mu\text{m}$ spatial resolution and pixel size, and photometry was extracted following the procedure explained in Sect. 3.1. We use a CO-to- H_2 conversion factor of $X(\text{CO}) = \frac{N_{\text{H}_2}}{I_{\text{CO}(1-0)}} = 4.0 \times 10^{20} \text{ cm}^{-2}/(\text{K km s}^{-1})$, which is the one applied by [Druard et al. \(2014\)](#) and consistent with the metallicity of M 33. We then apply Eq. 3 from [Druard et al. \(2014\)](#), which assumes a constant $I_{\text{CO}(2-1)}/I_{\text{CO}(1-0)}$, to derive the molecular hydrogen mass M_{H_2} for each H II region. The HI mass is obtained using a conversion factor for HI of $1.8 \times 10^{18} \text{ cm}^{-2}/(\text{K km s}^{-1})$, as in [Gratier et al. \(2010\)](#). In both cases we take into account the fraction of helium mass with a correction of 37%. The total gas mass is the sum of the neutral HI and the molecular H_2 mass ($M_{\text{tot}} = M_{\text{HI}} + M_{\text{H}_2}$).

In Fig. 8 we show the total gas surface density $\Sigma_{\text{gas}}(M_{\text{HI}} + M_{\text{H}_2})$ versus the dust surface density Σ_{dust} for the H II regions in our sample. As in the other sections in the paper we use only those regions showing reliable fits ($\chi^2_{\text{red}} < 20$), and we also exclude 5 regions not presenting CO emission within the defined apertures. In general, the distribution in Fig. 8 tends to flatten at high Σ_{dust} , as it has been recently observed in the N11 star-forming complex of the LMC ([Galametz et al. 2015](#)). Analysing the distribution in more detail we see that two regimes separated at a value of $\Sigma_{\text{dust}} = 0.06 \text{ M}_{\odot}/\text{pc}^2$ seem to coexist, as was already shown for the LMC and SMC in [Roman-Duval et al. \(2014\)](#). The distributions of the $\Sigma_{\text{gas}}(M_{\text{HI}} + M_{\text{H}_2})$ and Σ_{dust} are

different for values higher and lower than $\Sigma_{\text{dust}} = 0.06 \text{ M}_{\odot}/\text{pc}^2$ with a p-value from the KS test of less than 1% in both cases. $\Sigma_{\text{dust}} \sim 0.06 \text{ M}_{\odot}/\text{pc}^2$ is a reference value to separate the diffuse atomic and molecular ISM at the metallicity of M 33. This value corresponds to a visual extinction of $A_V \sim 0.4 \text{ mag}$ (see [Roman-Duval et al. 2014](#)) and [Krumholz et al. \(2009\)](#) shows that the $\text{H I}-\text{H}_2$ transition occurs for $A_V = 0.2 - 0.4 \text{ mag}$ at $Z \sim 0.5 Z_{\odot}$ (see their Fig. 1). Regions with $\Sigma_{\text{dust}} < 0.06 \text{ M}_{\odot}/\text{pc}^2$ are in the H I diffuse regime, where a significant fraction of H_2 molecular gas is dissociated, while regions with $\Sigma_{\text{dust}} > 0.06 \text{ M}_{\odot}/\text{pc}^2$ correspond to a molecular phase where the H_2 is not dissociated. In our sample of regions, we obtain median values of $M_{\text{H}_2}/M_{\text{HI}} = 0.41 \pm 0.06$ and $M_{\text{H}_2}/M_{\text{HI}} = 0.88 \pm 0.08$, for the diffuse atomic and molecular regimes, confirming that $\Sigma_{\text{dust}} = 0.06 \text{ M}_{\odot}/\text{pc}^2$ indeed separates molecular and atomic dominated regions.

We treat the two regimes separately and perform linear fits in each one (see Fig. 8). The derived slopes account for the gas-to-dust ratio in both regimes. The slope for the H I diffuse regime, 390 ± 68 , is closer to the value of the gas-to-dust ratio expected from the metallicity of M 33, (gas-to-dust ~ 325 , following the empirical broken power law given by [Rémy-Ruyer et al. 2014](#)) than the gas-to-dust ratio derived for the molecular regime, 67 ± 11 . Note, however, that other gas-to-dust ratios derived for M 33 using modified black body fitting range from 250 to 180, e.g. [Kramer et al. \(2010\)](#) and [Hermelo et al. \(2016\)](#). All of this shows the importance of using physically-motivated dust models as the results might change significantly depend-

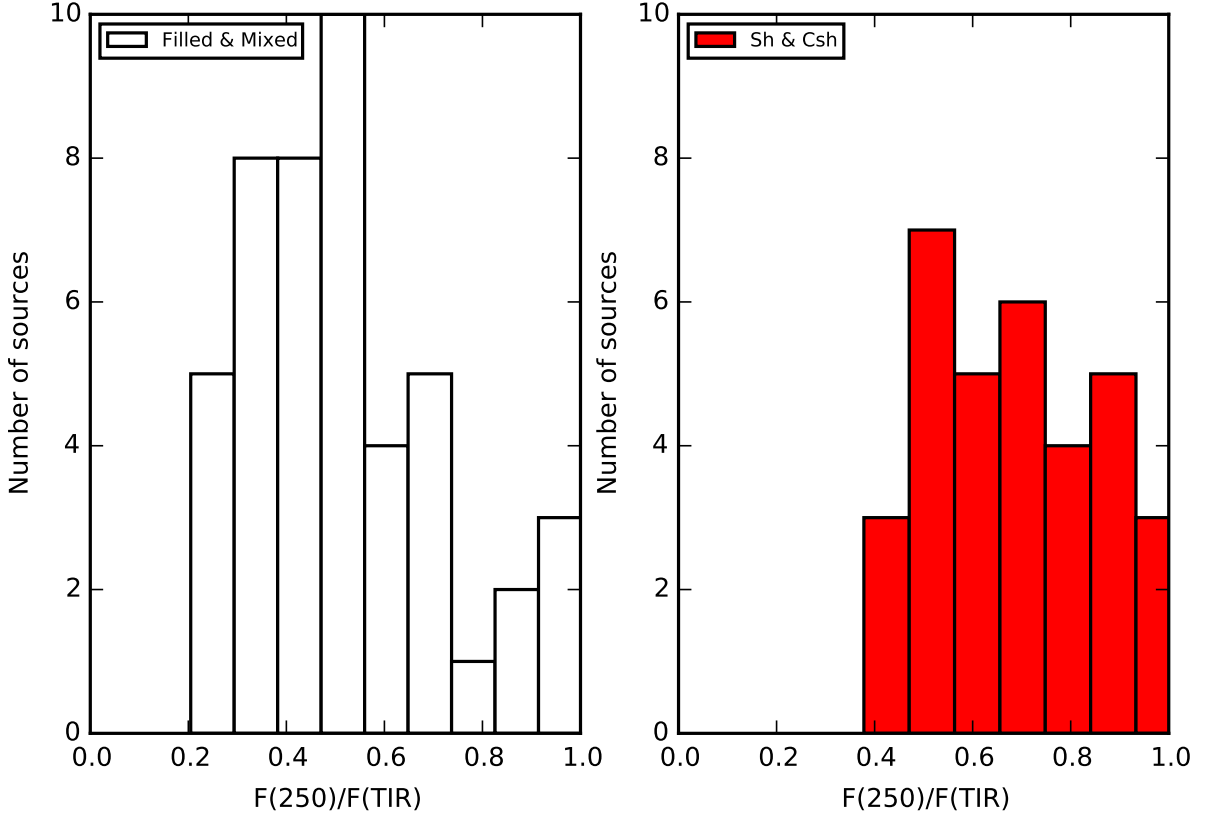


Fig. 7. $250\,\mu\text{m}$ emission relative to the TIR emission distribution for both *filled* and *mixed* together, and *shell* morphologies. The TIR emission is obtained using the prescription given by Boquien et al. (2011) including SPIRE and *Herschel* data from 24 to $250\,\mu\text{m}$.

ing on the used model. The slope obtained from the fit in the molecular regime gives a value ~ 5 times lower than the one derived in the H I diffuse regime, in agreement with the difference found between the slopes of both regimes observed in the LMC by Roman-Duval et al. (2014).

These authors present a detailed study of the possibilities causing the different slopes. One of the options is a different $X(\text{CO})$ factor for the diffuse atomic and molecular regimes. However, in order to bring the slopes of both regimes into agreement with the gas-to-dust ratio expected from the metallicity in M 33 we would need a higher $X(\text{CO})$ factor in the molecular dense regime. Recent models from Shetty et al. (2011) show the opposite, the $X(\text{CO})$ factor would decrease in denser regions. Other physical explanations proposed by Roman-Duval et al. (2014) are the existence of grain coagulation and/or accretion of gas-phase metals onto dust grains. Grain coagulation would imply a constant dust mass fraction, as in this process it is the dust size distribution which is altered, keeping the total dust mass constant. Coagulation of VSGs into BGs can produce an enhancement in the dust opacity at long wavelengths (Köhler et al. 2012, 2015), and thus the emissivity of the BGs would be enhanced in the FIR part of the SED. The result would be an overestimation of the dust mass. In the grain accretion process, gas-phase metals will be incorporated to the dust mass and thus will produce an increase of the dust-to-gas ratio. In other to shed light onto the physical mechanisms that can cause the difference in the slopes for both regimes, we plan to perform a detailed study of the dust-to-gas ratio variations in M 33 using DustEM

models selecting an appropriate sample of spatial regions in this galaxy, characteristic of the H I and molecular diffuse regimes (Relaño et al. in prep).

5. Spatially resolved analysis: NGC 604 and NGC 595

The spatial resolution of *Herschel* data allows us to analyse the interior of the largest and most luminous H II regions in M 33: NGC 604 and NGC 595. The $H\alpha$ emission of NGC 604 reveals the presence of large cavities of ionised gas (see Fig. 2 in Relaño & Kennicutt 2009) produced by the stellar winds coming from the central star clusters. Stellar population studies in this region present evidence of Wolf Rayet (WR) stars (Hunter et al. 1996) and red supergiants (RSGs) (Eldridge & Relaño 2011), showing two distinct formation episodes with ages 3.2 ± 1.0 Myr and 12.4 ± 2.1 Myr (Eldridge & Relaño 2011).

NGC 595 is the second most luminous H II region in M 33. The $H\alpha$ emission presents an open arc structure with a bright knot in the centre where the most massive stars are located (Relaño et al. 2010). The region also hosts numerous OB-type and RSG stars (Malumuth et al. 1996), as well as WR stars (Drissen et al. 2008). Malumuth et al. (1996) derived an age of 4.5 ± 1.0 Myr for the stellar population of NGC 595, which was confirmed later by Pellerin (2006). Pérez-Montero et al. (2011) performed a detailed modelling of NGC 595 using CLOUDY (Ferland et al. 1998) in a set of concentric elliptical annuli. These authors were able to fit the optical integral field spectroscopic

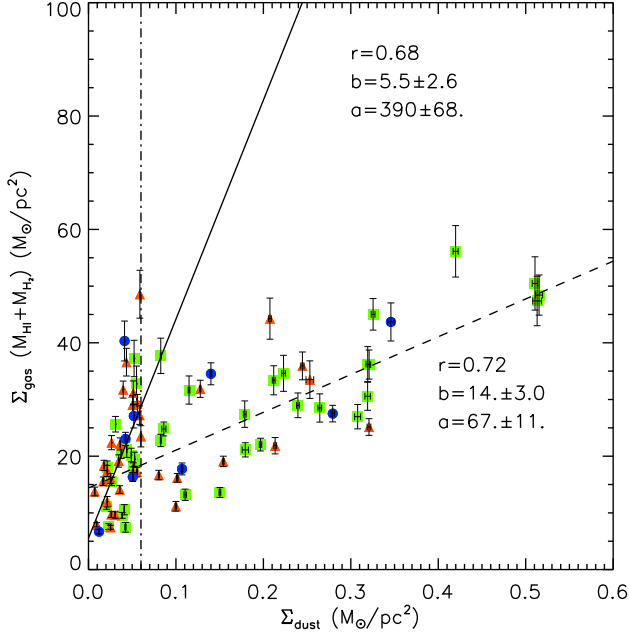


Fig. 8. Total gas surface density versus the dust surface density for the H II regions in our sample with fits presenting $\chi^2_{\text{red}} < 20$. We have also excluded 5 regions that do not show CO emission. The colour code represents the morphological classification of the sample, as in Fig. 5. The continuous line represents the fit including only regions with $\Sigma_{\text{dust}} < 0.06 \text{ M}_{\odot}/\text{pc}^2$, while the dashed line shows the fit for regions with $\Sigma_{\text{dust}} \geq 0.06 \text{ M}_{\odot}/\text{pc}^2$. a , b , and r represent the slope, intercept and correlation coefficient of the linear fits.

observations from Relaño et al. (2010) and mid-infrared observations from *Spitzer*. The $8\mu\text{m}/24\mu\text{m}$ ratio was successfully fitted with a dust-to-gas ratio which increases radially from the center to the outer parts of the region. The spatial distribution of the dust emission at $24\mu\text{m}$ correlates with the emission at $\text{H}\alpha$ for both H II regions, showing that there is hot dust mixed with the ionised gas in both objects (Relaño & Kennicutt 2009).

For the whole surface of NGC 604 and NGC 595 we perform a pixel-by-pixel SED modelling using DustEM and derive maps for each free parameter in the fit. We impose a limit in the surface brightness at $250\mu\text{m}$ to constrain the spatial emission of the H II regions and to discard pixels with low surface brightness having high uncertainties in their fluxes. We assume a 4 Myr and 10^4 M_{\odot} star cluster ISRF which accounts for the age and stellar mass of the two regions.

5.1. Maps of the relative mass abundance of grains

In Figs. 9 and 10 we show the results of the SED fitting on a pixel-by-pixel basis. F_0 correlates with FUV emission, which seems plausible as F_0 is a measurement of the ISRF intensity coming from the stars within the region. The spatial distribution of the $Y_{\text{VSG}}/Y_{\text{TOTAL}}$ map in both regions resembles the form of arcs and shells bordering the $\text{H}\alpha$ emission, and the relative fraction of PAHs, $Y_{\text{PAH}}/Y_{\text{TOTAL}}$, tends to be higher around the region. Finally, $Y_{\text{BG}}/Y_{\text{TOTAL}}$ distribution at the central areas of both regions tends to show high values at the location of high emission in CO. All these maps show that the relative mass abundance of

each grain type changes within the region depending on the local properties of the environment.

5.2. Signature of dust evolution within the regions

Evolution of the interstellar dust implies a redistribution of the dust mass in the different grain types via coagulation of small grains or fragmentation of large ones. Thus, a map of the relative mass fraction of VSG to BG would show the locations where these processes might take place. In both maps in Fig. 11 we can see maxima in $Y_{\text{VSG}}/Y_{\text{BG}}$ that seem to be bordering the $\text{H}\alpha$ emission. Jones et al. (1996) predict that the fragmentation of BGs into VSGs occurs for shocks with velocities of at least of 50 km s^{-1} . Therefore, we expect the presence of expanding structures with similar velocities at the location of $Y_{\text{VSG}}/Y_{\text{BG}}$ enhancements. Yang et al. (1996) studied the kinematics of NGC 604 and found five shell structures within the region with expansion velocities of $40\text{--}125 \text{ km s}^{-1}$ traced by the $\text{H}\alpha$ emission line. The approximate locations of the centre of the shells are depicted in Fig. 11 with numbers. All of them are within the area where the maxima of $Y_{\text{VSG}}/Y_{\text{BG}}$ are located. The kinematics of the ionised gas in the interior of NGC 595 was studied by Lagrois & Joncas (2009). These authors found two expanding shells located close to the position where the maximum of $Y_{\text{VSG}}/Y_{\text{BG}}$ occurs and estimated a mean expansion velocity for both shells of $\sim 20 \text{ km s}^{-1}$.

5.3. CO emission

In Fig. 12 we compare the $Y_{\text{PAH}}/Y_{\text{TOTAL}}$ maps with CO(2–1) intensity distribution from Druard et al. (2014). We can see that the $Y_{\text{PAH}}/Y_{\text{TOTAL}}$ distribution follows the CO(2–1) emission with the maximum in CO intensity corresponding to a minimum of $Y_{\text{PAH}}/Y_{\text{TOTAL}}$. The most intense CO(2–1) knot in NGC 604 is located close to the source 1 of Martínez-Galarza et al. (2012). These authors observed NGC 604 with the *Spitzer Infrared Spectrograph* (IRS) and selected 7 sources of interest based on their IRAC colours. In the left panel of Fig. 12 we show the location of sources 1 and 4, which are the ones exhibiting the highest *softness* parameter η' in the MIR¹⁰, a tracer of the hardness of the ISRF. Besides, sources 1 and 4 also present the highest $(6.2\mu\text{m}+7.7\mu\text{m}+8.6\mu\text{m})/11.3\mu\text{m}$ ratio. The $11.3\mu\text{m}$ PAH feature is associated to neutral PAHs, while $6.2\mu\text{m}$, $7.7\mu\text{m}$ and $8.6\mu\text{m}$ are associated to ionised PAHs. Therefore, at the location of sources 1 and 4, where a minimum in the $Y_{\text{PAH}}/Y_{\text{TOTAL}}$ distribution is located, there is the highest ionised/neutral PAH ratio and the hardest spectrum of all the sources analysed by Martínez-Galarza et al. (2012). The anti-correlation $Y_{\text{PAH}}/Y_{\text{TOTAL}}$ –hardness of ISRF provides evidence that the PAHs appear to be destroyed in places where the ISRF is strong and hard, as it has also been suggested in previous studies (Madden et al. 2006; Wu et al. 2006; Lebouteiller et al. 2007).

The hardness of the ISRF at this particular location within NGC 604 might be produced by newly formed massive stars. Source 1 in left panel of Fig. 12 is related to the maxima in CO(2–1) emission within the region and corresponds to the molecular cloud NMA-8, the most massive one in NGC 604 (Miura et al. 2010). Miura et al. (2010) also studied the HCN emission distribution, a tracer of dense regions in molecular clouds where star formation can occur. They found that there is a HCN cloud at the location of NMA-8 whose maximum is shifted from the maximum of NMA-8 towards the centre of the

¹⁰ $\eta' = \frac{I(\text{[Ne II]}12.8\mu\text{m})/I(\text{[Ne III]}15.6\mu\text{m})}{I(\text{[S III]}18.7\mu\text{m})/I(\text{[S IV]}10.5\mu\text{m})}$, as it is defined in Pérez-Montero & Vílchez (2009)

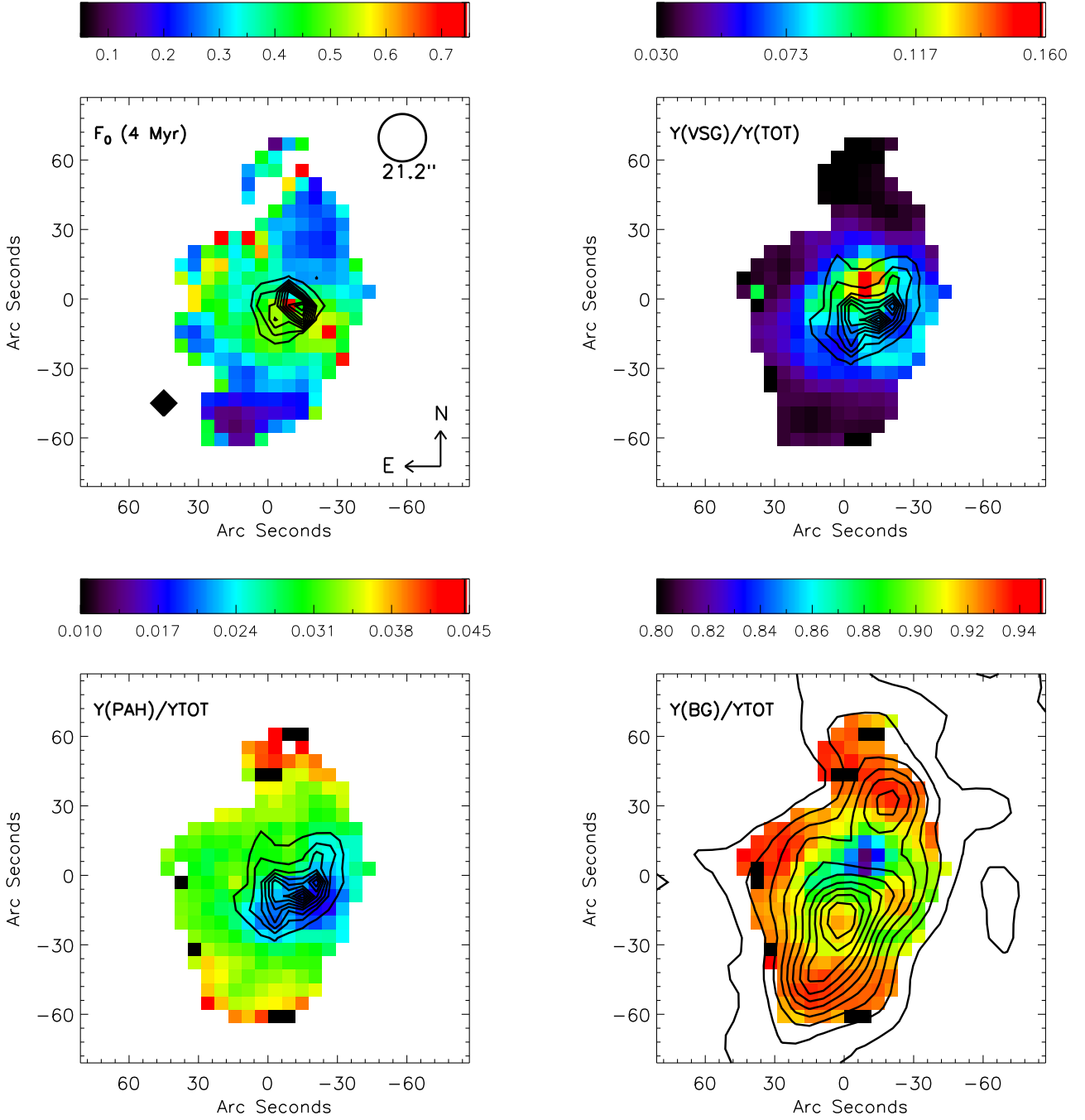


Fig. 9. F_0 (top-left), Y_{VSG}/Y_{TOTAL} (top-right), Y_{PAH}/Y_{TOTAL} (bottom-left), and Y_{BG}/Y_{TOTAL} (bottom-right) distribution maps of NGC 604 obtained using DustEM with an ISRF representing a 4 Myr star cluster given. The contours are FUV, $H\alpha$, $H\alpha$, and CO emission for the F_0 , Y_{VSG}/Y_{TOTAL} , Y_{PAH}/Y_{TOTAL} , and Y_{BG}/Y_{TOTAL} distribution maps, respectively. The spatial resolution of the contours are $4.4''$, $6.6''$, $3.0''$, and $20''$, respectively.

region. They concluded that NMA-8 is a dense molecular cloud that could be in a stage of ongoing massive star formation. At the maxima of NMA-8 Relaño & Kennicutt (2009) found a difference between the extinction derived from the Balmer emission and the extinction derived from the $H\alpha$ - $24\mu m$ ratio. The difference (also reported by Maíz-Apellániz et al. 2004, comparing Balmer and radio extinctions) could be produced if the surface of the molecular cloud has a shell morphology that would produce a lower value of the Balmer extinction. Relaño & Kennicutt (2009)

suggested that there could be embedded star formation at this location using Color Magnitude Diagram analysis of NGC 604.

In the bottom-left panels of Figs. 9 and 10 we compare the CO(2–1) emission distribution with the distribution of Y_{BG}/Y_{TOTAL} for NGC 604 and NGC 595, respectively. The maxima of CO intensity is correlated with local maxima of the Y_{BG}/Y_{TOTAL} in both regions. This shows that CO is more closely related to the total dust mass, traced by the mass fraction of BGs, than to the PAH abundance in these regions. For NGC 595, the distribution of Y_{BG} follows the same radial pattern as the dust-

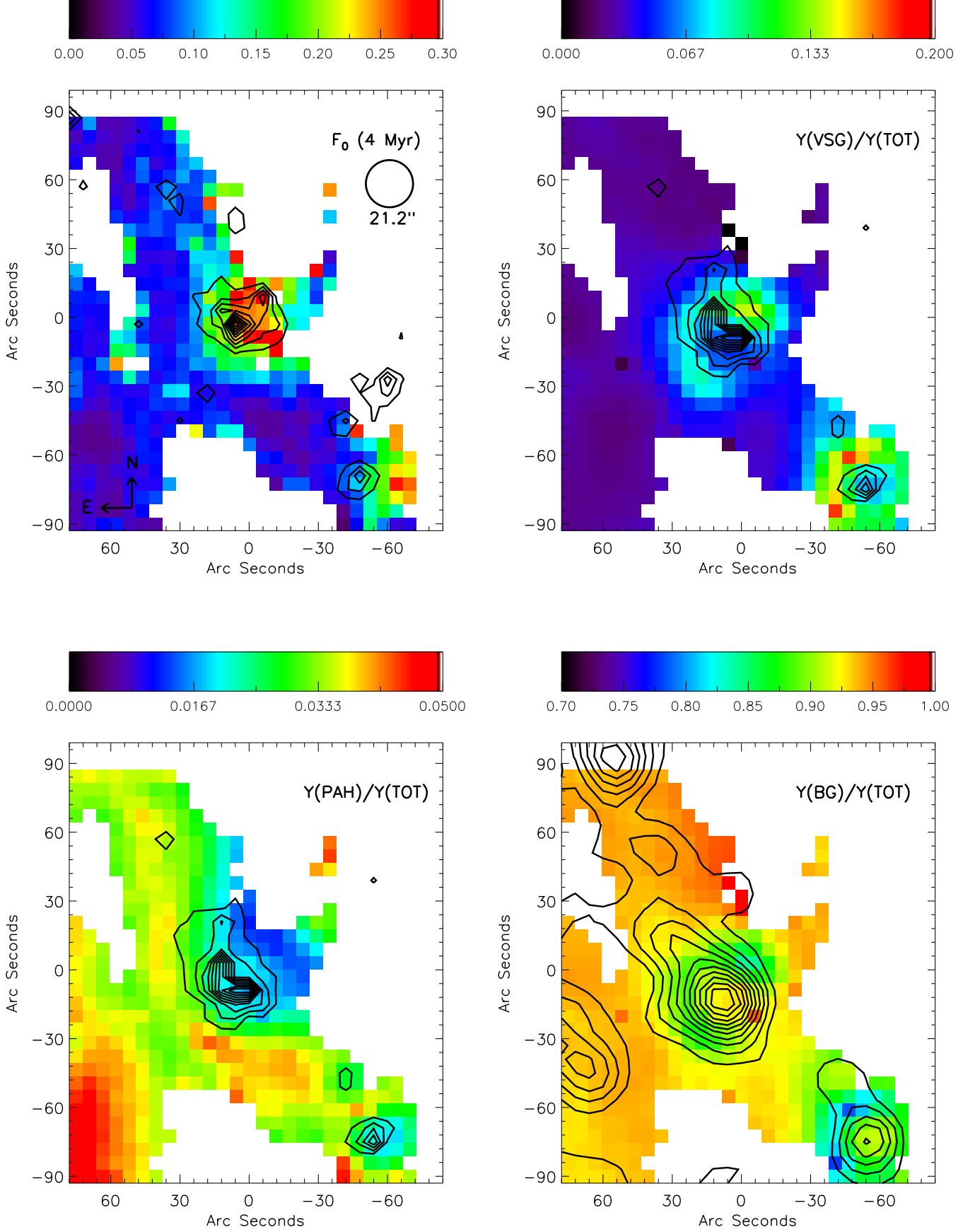


Fig. 10. F_0 (top-left), Y_{VSG}/Y_{TOTAL} (top-right), Y_{PAH}/Y_{TOTAL} (bottom-left), and Y_{BG}/Y_{TOTAL} (bottom-right) distribution maps of NGC 595 obtained using DustEM with an ISRF representing a 4 Myr star cluster, as it was done in previous sections. The contours are FUV, $H\alpha$, $H\alpha$, and CO emission for the F_0 , Y_{VSG}/Y_{TOTAL} , Y_{PAH}/Y_{TOTAL} , and Y_{BG}/Y_{TOTAL} distribution maps, respectively. The spatial resolution of the contours are 4.4", 6.6", 3.0", and 20", respectively.

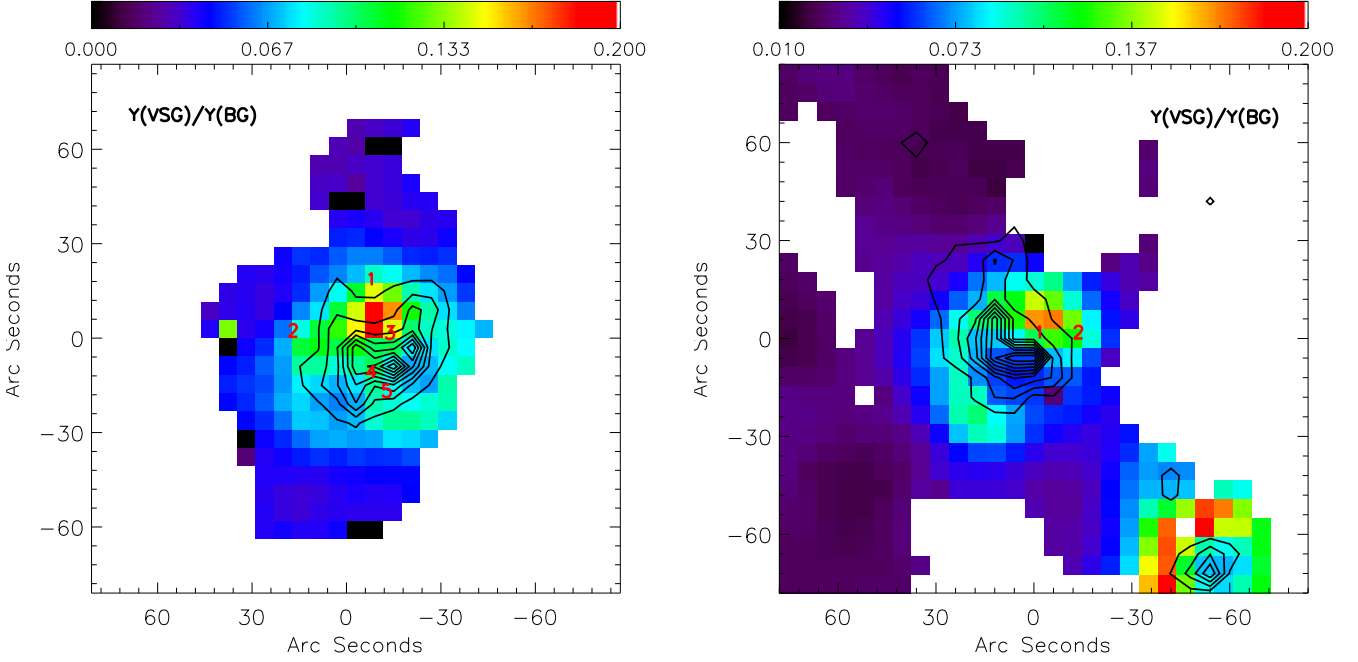


Fig. 11. Y_{VSG}/Y_{BG} distribution map for NGC 604 (left) and NGC 595 (right) obtained using DustEM code with a 4 Myr star cluster ISRF for NGC 604 and for NGC 595 and *Desert* dust model. The contours correspond to the continuum-subtracted $H\alpha$ image at high resolution ($6''$) and the numbers refer to the location of the expanding ionized gas shells observed by Yang et al. (1996) for NGC 604 and Lagrois & Joncas (2009) for NGC 595. Pixel size is $6''$.

to-gas ratio obtained from the modelling of the region performed by Pérez-Montero et al. (2011). These authors found that, in order to fit the radial trend of the $8\mu\text{m}/24\mu\text{m}$ ratio, the dust-to-gas ratio assumed in the model needed to increase from the centre to the outer parts of the regions. Whether a change in the dust-to-gas ratio is related to a change in the Y_{BG}/Y_{TOTAL} due to grain coagulation or reformation requires a detailed study which is outside of the scope of this paper.

6. Summary and conclusions

We analyse the SEDs of a sample of 119 H II regions classified in M33 as *filled*, *mixed* and *shell* and *clear shell* regions. The performed classification has been based on the $H\alpha$ emission distribution of each object and represents different star-gas-dust spatial configurations within the regions. We update and complete the observed SED of Paper I with new data from *Herschel* at $70\mu\text{m}$, WISE at $3.4\mu\text{m}$, $4.6\mu\text{m}$, $12\mu\text{m}$, and $22\mu\text{m}$, and LABOCA at $870\mu\text{m}$. We study the physical properties of the dust under different environments fitting the observed SED of each region with the dust model of Compiègne et al. (2011) and analysing the results in terms of the region morphology. We analyse the relative mass for each grain type for the best SED fit of each object in our sample with two different ISRF: a *Mathis* ISRF corresponding to the default solar neighbourhood (Mathis et al. 1983) and a more realistic one of a young 4 Myr cluster

with a fixed stellar mass of $10^4 M_{\odot}$. We also use the approximation of a MBB to describe the emission of the dust and to fit the IR part of the observed SED. Hereafter, we summarise our main results.

- All the mass ratios obtained with the modelling were independent of the shape of the ISRF except for PAHs. Y_{PAH}/Y_{TOTAL} is a factor of 2-10 higher assuming a *Mathis* ISRF, which shows the difficulty in constraining the relative abundance of PAHs with the models used here. BGs represent the highest fraction of dust mass in the regions ($\sim 90\%$), while the relative mass of the PAHs is in general low (1-10%).
- Y_{VSG}/Y_{TOTAL} is higher for *filled* and *mixed* regions by a factor of ~ 1.7 than for regions classified as *shells* and *clear shells*. The difference is the same when we apply the classic *Desert* dust model. We interpret this result within the dust evolution framework proposed by Jones et al. (1996) where large grains can be disrupted by strong shocks. The regions classified as *filled* and *mixed* have high-velocity $\sim 50\text{-}90\text{ km s}^{-1}$ expansive structures that can produce an enhancement of the relative fraction of VSGs, while the *shells* and *clear shells* present a more quiescent environment where the BG can survive or reform.
- We derived an estimation of the dust temperature using the equilibrium temperature of the aSil grains provided by DustEM. We found no difference in the temperature for both

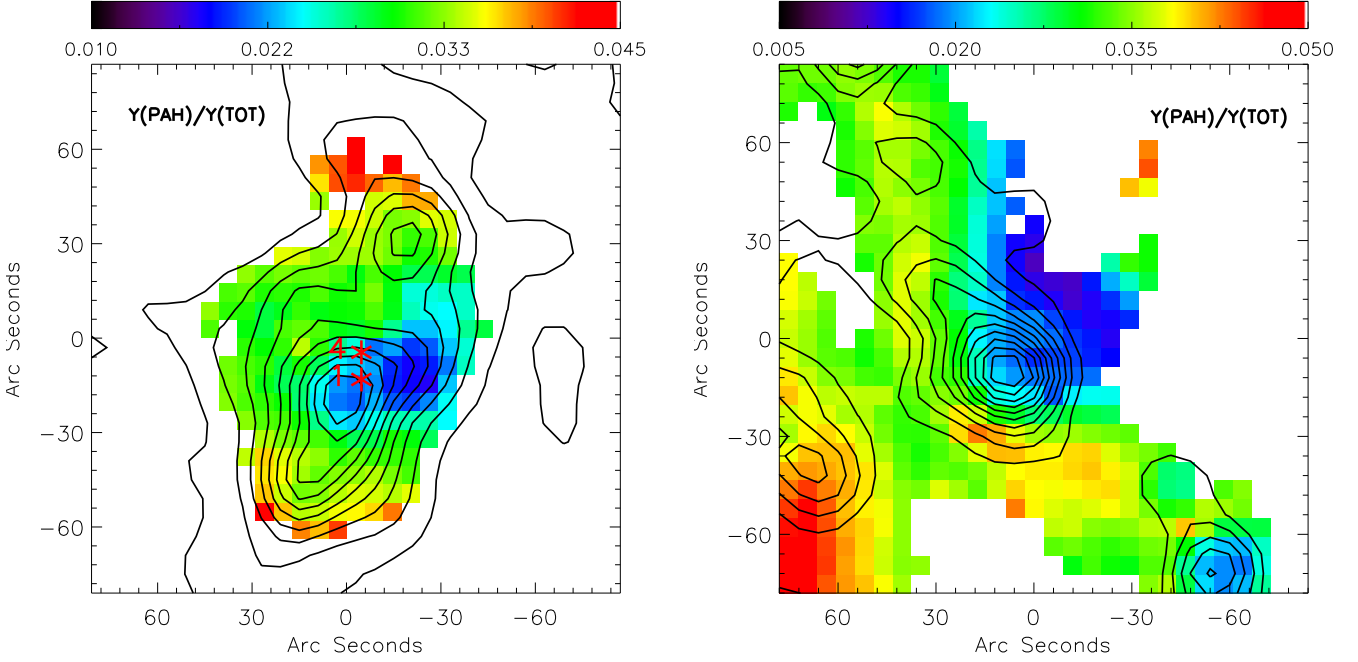


Fig. 12. $Y_{\text{PAH}}/Y_{\text{TOTAL}}$ distribution map for NGC 604 (left) and NGC 595 (right) as shown in Figs. 9 and 10 overlaid with CO(2–1) intensity contours from Druard et al. (2014). The spatial resolution for both maps are $20''$ and the pixel size is $6''$.

filled and *mixed* regions and *shell* objects. However, a MBB analysis gives temperatures slightly higher than 3σ for the *filled* and *mixed* regions ($T=17.9 \pm 0.6$ K), than for the *shell* objects ($T=15.5 \pm 0.6$ K). This could be due to differences in the total dust opacity of the different types of H II regions and/or due to a different spatial distribution of dust and stars within the type of the regions.

- We derive the gas-to-dust ratio for the H II regions in our sample from the slope of the dust-gas surface density relation. We find two different slopes in the relation: regions with $\Sigma_{\text{dust}} < 0.06 M_{\odot}/\text{pc}^2$, corresponding to the H I diffuse regime, present a gas-to-dust ratio of 390 ± 68 compatible with the expected value if we assume that the gas-to-dust ratio scales linearly with metallicity. Regions with $\Sigma_{\text{dust}} \geq 0.06 M_{\odot}/\text{pc}^2$, corresponding to a H_2 molecular phase, present a flatter dust-gas surface density distribution, with a corresponding gas-to-dust ratio of 67 ± 11 . These variations might imply that grain coagulation and/or gas-phase metals incorporation to the dust mass is occurring in the interior of the H II regions in M 33.
- In a spatially resolved analysis, we perform a pixel-by-pixel SED fitting of the whole surface of the two most luminous H II regions in M33: NGC 604 and NGC 595. We derive maps of the relative mass fraction of VSG to BG ($Y_{\text{VSG}}/Y_{\text{BG}}$) for NGC 604 and NGC 595. We find local maxima of $Y_{\text{VSG}}/Y_{\text{BG}}$ correlated to expansive ionised gas structures with velocities $\gtrsim 50 \text{ km s}^{-1}$ within the regions. This agrees with the results of Jones et al. (1996), who predict

the fragmentation of BGs into VSGs due to shocks with velocities of at least 50 km s^{-1} .

- $Y_{\text{PAH}}/Y_{\text{TOTAL}}$ distribution for NGC 604 and NGC 595 follows the CO(2–1) emission, with the maximum in CO intensity corresponding to minimum of $Y_{\text{PAH}}/Y_{\text{TOTAL}}$. A deeper analysis using IRS data for NGC 604 shows that the minimum of $Y_{\text{PAH}}/Y_{\text{TOTAL}}$ in this region corresponds to a high ionised/neutral PAH ratio and the location of a hard ISRF. This shows evidence that the PAHs are destroyed in places where the ISRF is strong and hard.

The dust emission in the IR has been shown to be a tracer of the star formation in a galaxy and correlations, albeit with dispersions, have been presented in the literature between the IR bands and other, more direct, star formation rate tracers, as the $\text{H}\alpha$ emission coming from the ionised gas heated by recently formed stars. The emission in the $24 \mu\text{m}$ band has been particularly successful in tracing the star formation in H II regions, as it corresponds to the warm dust mixed with the hot ionised gas at these locations (see e.g. Calzetti et al. 2005). However, we show here that the relative fraction of VSGs, which are the main contributors to the $24 \mu\text{m}$ band emission, is not constant but changes (a factor of 1.7) depending on the morphology (and the evolutionary state) of the region. This effect introduces an uncertainty in the correlation between the $24 \mu\text{m}$ and $\text{H}\alpha$ emission, which is expected to contribute to the dispersion in the observed empirical correlation. Understanding the physical properties of the dust, in particular the variation of the VSGs in different H II re-

gions, will help us to better understand the uncertainties in the empirical correlations between SFR tracers.

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Appendix A: Fluxes

Table A.1. Logarithmic of the fluxes from FUV to *Spitzer* 8.0 μm band of our set of H II regions in mJy Hz obtained with centres and apertures given in Table B.1 in [Paper I](#). FUV, NUV and H α fluxes have been corrected for Galactic extinction assuming a colour excess of $E(B - V) = 0.07$ mag ([van den Bergh 2000](#)) and [Cardelli et al. \(1989\)](#) extinction law with $R_V = 3.1$. All the fluxes have been background subtracted. The errors include the uncertainties in the calibration and background subtraction. We did not take into account negative fluxes higher than the corresponding errors, in these cases the fluxes are represented by ***.

ID	F(FUV) log(mJy Hz)	F(NUV) log(mJy Hz)	F(H α) log(mJy Hz)	F(3.4 μm) log(mJy Hz)	F(3.6 μm) log(mJy Hz)	F(4.5 μm) log(mJy Hz)	F(4.6 μm) log(mJy Hz)	F(5.8 μm) log(mJy Hz)	F(8.0 μm) log(mJy Hz)
1	16.18 \pm 0.00	16.15 \pm 0.00	14.22 \pm 0.07	14.77 \pm 0.02	14.79 \pm 0.03	14.54 \pm 0.05	14.50 \pm 0.02	15.01 \pm 0.05	15.24 \pm 0.07
2	15.66 \pm 0.01	15.58 \pm 0.01	13.67 \pm 0.07	14.58 \pm 0.02	14.62 \pm 0.03	14.52 \pm 0.05	14.39 \pm 0.02	14.80 \pm 0.05	14.92 \pm 0.07
3	16.13 \pm 0.00	16.01 \pm 0.00	14.11 \pm 0.07	14.66 \pm 0.02	14.70 \pm 0.03	14.47 \pm 0.05	14.32 \pm 0.02	14.68 \pm 0.05	14.87 \pm 0.07
4	15.92 \pm 0.01	15.83 \pm 0.01	14.11 \pm 0.07	14.57 \pm 0.02	14.48 \pm 0.04	14.25 \pm 0.06	14.23 \pm 0.03	14.57 \pm 0.06	14.73 \pm 0.07
5	15.92 \pm 0.00	15.82 \pm 0.00	13.70 \pm 0.07	14.35 \pm 0.02	14.35 \pm 0.03	14.15 \pm 0.05	14.03 \pm 0.02	14.73 \pm 0.05	14.96 \pm 0.07
6	16.22 \pm 0.00	16.09 \pm 0.00	14.23 \pm 0.07	14.38 \pm 0.05	14.46 \pm 0.05	14.44 \pm 0.05	14.23 \pm 0.04	14.63 \pm 0.07	15.10 \pm 0.07
7	16.19 \pm 0.00	16.14 \pm 0.00	14.65 \pm 0.07	14.44 \pm 0.03	14.53 \pm 0.03	14.48 \pm 0.05	14.37 \pm 0.02	14.82 \pm 0.05	15.20 \pm 0.07
8	15.04 \pm 0.02	14.92 \pm 0.02	13.47 \pm 0.07	13.87 \pm 0.05	14.01 \pm 0.04	14.06 \pm 0.05	13.91 \pm 0.02	14.24 \pm 0.05	14.45 \pm 0.07
9	15.47 \pm 0.02	15.45 \pm 0.02	13.65 \pm 0.07	14.30 \pm 0.04	14.11 \pm 0.08	13.68 \pm 0.14	13.56 \pm 0.15	14.38 \pm 0.07	14.35 \pm 0.09
10	16.06 \pm 0.01	15.95 \pm 0.01	13.77 \pm 0.07	14.47 \pm 0.03	14.54 \pm 0.03	14.27 \pm 0.05	14.15 \pm 0.03	14.55 \pm 0.05	14.65 \pm 0.07
11	15.31 \pm 0.01	15.24 \pm 0.02	12.85 \pm 0.07	13.49 \pm 0.11	13.52 \pm 0.11	13.55 \pm 0.07	13.52 \pm 0.05	13.79 \pm 0.08	13.98 \pm 0.07
12	15.55 \pm 0.00	15.43 \pm 0.01	13.66 \pm 0.07	14.22 \pm 0.03	14.16 \pm 0.05	14.00 \pm 0.06	13.94 \pm 0.04	14.43 \pm 0.05	14.59 \pm 0.07
13	15.15 \pm 0.03	15.01 \pm 0.03	13.33 \pm 0.07	*** \pm ***	*** \pm ***	*** \pm ***	*** \pm ***	13.91 \pm 0.15	14.13 \pm 0.13
14	15.69 \pm 0.01	15.66 \pm 0.01	13.53 \pm 0.07	13.95 \pm 0.10	14.15 \pm 0.06	13.85 \pm 0.08	13.55 \pm 0.11	14.65 \pm 0.05	14.90 \pm 0.07
15	15.92 \pm 0.01	15.84 \pm 0.00	13.74 \pm 0.07	14.28 \pm 0.03	14.35 \pm 0.03	14.04 \pm 0.05	13.89 \pm 0.04	14.50 \pm 0.05	14.74 \pm 0.07
16	15.47 \pm 0.00	15.37 \pm 0.01	13.63 \pm 0.07	15.59 \pm 0.01	14.12 \pm 0.05	15.24 \pm 0.04	15.18 \pm 0.01	15.03 \pm 0.04	14.83 \pm 0.07
17	16.32 \pm 0.01	16.26 \pm 0.00	14.40 \pm 0.07	14.78 \pm 0.03	14.80 \pm 0.04	14.60 \pm 0.05	14.48 \pm 0.03	14.99 \pm 0.06	15.28 \pm 0.07
18	16.10 \pm 0.00	15.98 \pm 0.00	14.11 \pm 0.07	14.09 \pm 0.04	14.27 \pm 0.03	14.13 \pm 0.05	14.06 \pm 0.03	13.54 \pm 0.26	14.55 \pm 0.07
19	15.97 \pm 0.00	15.85 \pm 0.00	13.77 \pm 0.07	14.46 \pm 0.03	14.49 \pm 0.04	14.25 \pm 0.05	14.14 \pm 0.03	14.64 \pm 0.05	14.89 \pm 0.07
20	16.14 \pm 0.00	16.05 \pm 0.00	14.21 \pm 0.07	15.19 \pm 0.01	15.19 \pm 0.02	14.95 \pm 0.04	14.89 \pm 0.01	15.31 \pm 0.04	15.54 \pm 0.07
21	16.08 \pm 0.00	15.99 \pm 0.00	14.29 \pm 0.07	15.06 \pm 0.01	15.12 \pm 0.02	14.93 \pm 0.04	14.87 \pm 0.01	15.52 \pm 0.04	15.74 \pm 0.07
22	16.30 \pm 0.00	16.21 \pm 0.00	14.36 \pm 0.07	14.81 \pm 0.02	14.86 \pm 0.02	14.64 \pm 0.05	14.54 \pm 0.02	15.13 \pm 0.04	15.38 \pm 0.07
23	15.95 \pm 0.00	15.87 \pm 0.00	14.38 \pm 0.07	14.52 \pm 0.03	14.66 \pm 0.03	14.55 \pm 0.05	14.47 \pm 0.02	15.23 \pm 0.04	15.52 \pm 0.07
24	15.92 \pm 0.00	15.84 \pm 0.01	14.06 \pm 0.07	14.64 \pm 0.03	14.67 \pm 0.03	14.41 \pm 0.05	14.34 \pm 0.03	15.00 \pm 0.05	15.27 \pm 0.07
25	16.32 \pm 0.00	16.28 \pm 0.00	14.45 \pm 0.07	14.95 \pm 0.02	14.99 \pm 0.03	14.79 \pm 0.05	14.71 \pm 0.02	15.24 \pm 0.04	15.48 \pm 0.07
26	15.75 \pm 0.01	15.68 \pm 0.01	13.74 \pm 0.07	*** \pm ***	14.05 \pm 0.15	13.80 \pm 0.15	13.51 \pm 0.22	14.84 \pm 0.05	15.15 \pm 0.07
27	15.82 \pm 0.02	15.70 \pm 0.02	13.63 \pm 0.07	13.95 \pm 0.14	13.76 \pm 0.25	13.62 \pm 0.18	13.66 \pm 0.14	14.82 \pm 0.06	15.09 \pm 0.07
28	15.86 \pm 0.01	15.76 \pm 0.01	14.62 \pm 0.07	15.28 \pm 0.01	15.20 \pm 0.02	14.98 \pm 0.04	14.91 \pm 0.02	15.11 \pm 0.05	15.27 \pm 0.07
29	16.52 \pm 0.00	16.40 \pm 0.00	14.57 \pm 0.07	15.11 \pm 0.02	15.16 \pm 0.03	15.15 \pm 0.04	15.10 \pm 0.01	15.59 \pm 0.04	15.87 \pm 0.07
30	16.00 \pm 0.00	15.88 \pm 0.00	14.44 \pm 0.07	14.81 \pm 0.02	14.83 \pm 0.03	14.60 \pm 0.05	14.58 \pm 0.02	15.07 \pm 0.05	15.36 \pm 0.07
31	15.36 \pm 0.02	15.31 \pm 0.02	13.53 \pm 0.07	14.28 \pm 0.06	14.34 \pm 0.06	14.07 \pm 0.07	13.75 \pm 0.11	14.88 \pm 0.05	15.06 \pm 0.07
32	15.60 \pm 0.01	15.49 \pm 0.02	13.63 \pm 0.07	14.85 \pm 0.02	14.89 \pm 0.03	14.71 \pm 0.05	14.63 \pm 0.02	15.22 \pm 0.04	15.55 \pm 0.07
33	15.65 \pm 0.01	15.57 \pm 0.01	13.21 \pm 0.07	14.28 \pm 0.07	14.08 \pm 0.12	13.95 \pm 0.12	13.69 \pm 0.14	14.22 \pm 0.15	14.27 \pm 0.15
34	15.28 \pm 0.02	15.20 \pm 0.02	13.29 \pm 0.07	14.49 \pm 0.04	14.48 \pm 0.04	14.10 \pm 0.07	13.97 \pm 0.07	14.70 \pm 0.05	14.94 \pm 0.07
35	15.47 \pm 0.01	15.32 \pm 0.01	13.85 \pm 0.07	14.88 \pm 0.02	15.00 \pm 0.02	14.95 \pm 0.04	14.84 \pm 0.01	15.24 \pm 0.04	15.43 \pm 0.07
36	15.35 \pm 0.01	15.25 \pm 0.01	13.14 \pm 0.07	14.11 \pm 0.03	14.16 \pm 0.03	13.76 \pm 0.06	13.74 \pm 0.04	13.86 \pm 0.09	14.21 \pm 0.08
37	15.74 \pm 0.03	15.61 \pm 0.04	14.02 \pm 0.07	15.27 \pm 0.03	15.29 \pm 0.03	14.97 \pm 0.05	14.90 \pm 0.04	15.58 \pm 0.05	15.87 \pm 0.07
38	15.71 \pm 0.00	15.60 \pm 0.01	13.48 \pm 0.07	14.28 \pm 0.02	14.25 \pm 0.04	14.02 \pm 0.06	13.81 \pm 0.05	13.80 \pm 0.18	14.43 \pm 0.07
39	14.60 \pm 0.06	14.76 \pm 0.05	12.90 \pm 0.07	14.16 \pm 0.15	14.17 \pm 0.15	13.89 \pm 0.15	13.79 \pm 0.15	13.85 \pm 0.22	14.52 \pm 0.08
40	*** \pm ***	*** \pm ***	13.23 \pm 0.07	*** \pm ***	*** \pm ***	*** \pm ***	*** \pm ***	14.17 \pm 0.15	14.21 \pm 0.10
41	15.83 \pm 0.02	15.79 \pm 0.02	14.37 \pm 0.07	15.11 \pm 0.02	15.17 \pm 0.03	14.99 \pm 0.05	14.95 \pm 0.02	15.73 \pm 0.04	16.03 \pm 0.07
42	15.96 \pm 0.01	15.83 \pm 0.01	14.40 \pm 0.07	14.73 \pm 0.07	14.85 \pm 0.05	14.77 \pm 0.05	14.74 \pm 0.03	15.43 \pm 0.05	15.76 \pm 0.07
43	15.24 \pm 0.01	15.09 \pm 0.01	13.11 \pm 0.07	14.01 \pm 0.03	14.12 \pm 0.03	13.92 \pm 0.06	13.83 \pm 0.04	13.74 \pm 0.15	14.12 \pm 0.09
44	16.42 \pm 0.00	16.33 \pm 0.00	15.09 \pm 0.07	15.55 \pm 0.01	15.60 \pm 0.02	15.45 \pm 0.04	15.39 \pm 0.01	15.92 \pm 0.04	16.21 \pm 0.07

Table A.1. continued.

ID	F(FUV) log(mJy Hz)	F(NUV) log(mJy Hz)	F(H α) log(mJy Hz)	F(3.4 μ m) log(mJy Hz)	F(3.6 μ m) log(mJy Hz)	F(4.5 μ m) log(mJy Hz)	F(4.6 μ m) log(mJy Hz)	F(5.8 μ m) log(mJy Hz)	F(8.0 μ m) log(mJy Hz)
45	15.47 \pm 0.02	15.32 \pm 0.02	13.60 \pm 0.07	14.62 \pm 0.05	14.69 \pm 0.03	14.39 \pm 0.05	14.32 \pm 0.03	14.85 \pm 0.05	15.12 \pm 0.07
46	14.63 \pm 0.14	14.53 \pm 0.14	13.32 \pm 0.07	14.34 \pm 0.09	14.47 \pm 0.07	14.37 \pm 0.06	14.24 \pm 0.05	14.91 \pm 0.05	15.20 \pm 0.07
47	15.83 \pm 0.01	15.74 \pm 0.01	13.99 \pm 0.07	14.76 \pm 0.03	14.73 \pm 0.04	14.63 \pm 0.05	14.60 \pm 0.02	15.13 \pm 0.05	15.41 \pm 0.07
48	14.86 \pm 0.17	14.53 \pm 0.32	13.70 \pm 0.07	15.18 \pm 0.02	15.20 \pm 0.03	13.60 \pm 0.18	14.77 \pm 0.03	14.01 \pm 0.20	14.73 \pm 0.07
49	15.82 \pm 0.00	15.76 \pm 0.01	14.14 \pm 0.07	14.50 \pm 0.05	14.51 \pm 0.05	14.81 \pm 0.05	14.77 \pm 0.03	15.37 \pm 0.05	15.56 \pm 0.07
50	16.16 \pm 0.00	16.05 \pm 0.00	14.15 \pm 0.07	14.64 \pm 0.02	14.71 \pm 0.03	14.28 \pm 0.06	14.16 \pm 0.04	14.67 \pm 0.05	15.00 \pm 0.07
51	15.56 \pm 0.05	15.41 \pm 0.07	13.68 \pm 0.07	14.55 \pm 0.04	14.66 \pm 0.04	14.53 \pm 0.05	14.40 \pm 0.02	15.00 \pm 0.05	15.26 \pm 0.07
52	16.17 \pm 0.01	16.04 \pm 0.01	14.06 \pm 0.07	14.93 \pm 0.05	14.99 \pm 0.05	14.70 \pm 0.06	14.35 \pm 0.03	15.04 \pm 0.05	15.33 \pm 0.07
53	16.22 \pm 0.00	16.22 \pm 0.00	13.88 \pm 0.07	14.68 \pm 0.03	14.63 \pm 0.03	14.05 \pm 0.08	14.23 \pm 0.05	15.18 \pm 0.06	15.46 \pm 0.08
54	16.15 \pm 0.01	16.09 \pm 0.01	14.46 \pm 0.07	15.28 \pm 0.02	15.28 \pm 0.03	14.97 \pm 0.05	14.90 \pm 0.03	14.03 \pm 0.15	14.80 \pm 0.08
55	15.87 \pm 0.00	15.77 \pm 0.00	14.03 \pm 0.07	14.06 \pm 0.06	14.04 \pm 0.08	13.92 \pm 0.10	13.67 \pm 0.12	15.46 \pm 0.05	15.77 \pm 0.07
56	15.90 \pm 0.00	15.80 \pm 0.01	13.77 \pm 0.07	14.87 \pm 0.02	14.85 \pm 0.03	14.61 \pm 0.04	14.54 \pm 0.02	14.80 \pm 0.04	14.98 \pm 0.07
57	16.35 \pm 0.01	16.22 \pm 0.02	14.41 \pm 0.07	15.43 \pm 0.02	15.36 \pm 0.03	15.07 \pm 0.05	15.10 \pm 0.02	15.83 \pm 0.04	16.13 \pm 0.07
58	15.22 \pm 0.02	15.10 \pm 0.03	13.44 \pm 0.07	14.19 \pm 0.08	14.37 \pm 0.06	14.16 \pm 0.06	14.24 \pm 0.03	14.50 \pm 0.06	14.84 \pm 0.07
59	15.52 \pm 0.00	15.39 \pm 0.01	13.64 \pm 0.07	13.99 \pm 0.07	14.14 \pm 0.06	13.96 \pm 0.07	13.71 \pm 0.07	14.30 \pm 0.06	14.70 \pm 0.07
60	16.04 \pm 0.00	15.95 \pm 0.00	13.73 \pm 0.07	13.78 \pm 0.18	14.09 \pm 0.10	14.12 \pm 0.06	13.86 \pm 0.06	14.35 \pm 0.06	14.71 \pm 0.07
61	15.45 \pm 0.01	15.31 \pm 0.01	13.69 \pm 0.07	14.36 \pm 0.02	14.26 \pm 0.04	13.99 \pm 0.06	14.08 \pm 0.02	14.39 \pm 0.06	14.67 \pm 0.07
62	16.65 \pm 0.01	16.60 \pm 0.01	14.51 \pm 0.07	16.06 \pm 0.01	16.05 \pm 0.02	15.77 \pm 0.04	15.71 \pm 0.01	15.96 \pm 0.05	16.16 \pm 0.07
63	15.87 \pm 0.02	15.89 \pm 0.02	14.21 \pm 0.07	14.40 \pm 0.18	14.55 \pm 0.13	14.30 \pm 0.12	14.31 \pm 0.11	15.32 \pm 0.05	15.62 \pm 0.07
64	16.10 \pm 0.01	16.05 \pm 0.00	13.88 \pm 0.07	13.93 \pm 0.28	14.33 \pm 0.11	13.97 \pm 0.15	13.84 \pm 0.16	14.42 \pm 0.15	14.54 \pm 0.24
65	15.14 \pm 0.07	14.84 \pm 0.15	13.63 \pm 0.07	14.55 \pm 0.09	14.48 \pm 0.10	14.08 \pm 0.14	14.08 \pm 0.12	14.96 \pm 0.06	15.31 \pm 0.08
66	15.96 \pm 0.01	15.91 \pm 0.01	14.48 \pm 0.07	14.90 \pm 0.03	14.94 \pm 0.04	14.76 \pm 0.05	14.71 \pm 0.02	15.33 \pm 0.05	15.62 \pm 0.07
67	15.43 \pm 0.00	15.32 \pm 0.01	13.37 \pm 0.07	13.63 \pm 0.06	13.68 \pm 0.06	13.52 \pm 0.07	13.36 \pm 0.05	14.04 \pm 0.06	14.41 \pm 0.07
68	15.77 \pm 0.01	15.65 \pm 0.01	13.70 \pm 0.07	15.03 \pm 0.03	14.96 \pm 0.04	14.58 \pm 0.06	14.68 \pm 0.03	14.94 \pm 0.05	15.06 \pm 0.07
69	16.10 \pm 0.02	16.06 \pm 0.02	13.84 \pm 0.07	15.10 \pm 0.02	15.10 \pm 0.03	14.83 \pm 0.05	14.80 \pm 0.02	15.19 \pm 0.05	15.50 \pm 0.07
70	14.65 \pm 0.27	14.89 \pm 0.14	14.04 \pm 0.07	14.95 \pm 0.04	14.95 \pm 0.05	14.73 \pm 0.06	14.74 \pm 0.03	15.37 \pm 0.05	15.69 \pm 0.07
71	15.60 \pm 0.02	15.53 \pm 0.02	13.16 \pm 0.07	14.43 \pm 0.04	14.52 \pm 0.04	14.27 \pm 0.05	14.25 \pm 0.03	15.01 \pm 0.05	15.32 \pm 0.07
72	16.12 \pm 0.01	16.07 \pm 0.01	14.27 \pm 0.07	14.81 \pm 0.08	14.89 \pm 0.07	14.66 \pm 0.07	14.58 \pm 0.06	15.44 \pm 0.05	15.75 \pm 0.07
73	15.89 \pm 0.04	15.57 \pm 0.09	14.37 \pm 0.07	15.23 \pm 0.04	15.34 \pm 0.04	15.09 \pm 0.05	15.03 \pm 0.03	15.72 \pm 0.05	16.03 \pm 0.07
74	15.44 \pm 0.02	15.27 \pm 0.02	13.80 \pm 0.07	13.76 \pm 0.11	13.93 \pm 0.09	13.77 \pm 0.08	13.61 \pm 0.08	14.69 \pm 0.05	14.98 \pm 0.07
75	15.24 \pm 0.02	14.96 \pm 0.04	13.59 \pm 0.07	14.12 \pm 0.09	14.13 \pm 0.09	13.84 \pm 0.12	13.92 \pm 0.07	14.89 \pm 0.05	15.20 \pm 0.07
76	15.11 \pm 0.05	14.92 \pm 0.07	13.63 \pm 0.07	14.03 \pm 0.14	14.05 \pm 0.15	13.79 \pm 0.15	13.45 \pm 0.30	14.01 \pm 0.33	14.59 \pm 0.18
77	16.04 \pm 0.01	15.95 \pm 0.01	14.29 \pm 0.07	15.19 \pm 0.03	15.19 \pm 0.03	14.81 \pm 0.05	14.73 \pm 0.03	15.43 \pm 0.05	15.80 \pm 0.07
78	16.14 \pm 0.01	16.07 \pm 0.01	14.47 \pm 0.07	15.02 \pm 0.02	15.08 \pm 0.03	14.90 \pm 0.05	14.88 \pm 0.02	15.51 \pm 0.04	15.79 \pm 0.07
79	15.13 \pm 0.07	14.84 \pm 0.13	13.39 \pm 0.07	14.01 \pm 0.14	13.60 \pm 0.36	13.39 \pm 0.32	13.70 \pm 0.15	14.68 \pm 0.06	15.10 \pm 0.07
80	15.54 \pm 0.01	15.40 \pm 0.02	13.58 \pm 0.07	13.99 \pm 0.03	14.10 \pm 0.04	14.01 \pm 0.06	13.94 \pm 0.03	14.34 \pm 0.07	14.51 \pm 0.07
81	14.88 \pm 0.04	14.43 \pm 0.14	13.27 \pm 0.07	14.02 \pm 0.14	13.97 \pm 0.16	14.06 \pm 0.07	13.88 \pm 0.09	14.64 \pm 0.05	14.99 \pm 0.07
82	15.56 \pm 0.01	15.41 \pm 0.01	13.44 \pm 0.07	13.50 \pm 0.28	13.92 \pm 0.12	13.58 \pm 0.20	13.66 \pm 0.12	14.29 \pm 0.12	14.42 \pm 0.08
83	15.37 \pm 0.01	15.20 \pm 0.02	13.29 \pm 0.07	13.65 \pm 0.07	13.74 \pm 0.08	13.58 \pm 0.09	13.31 \pm 0.11	14.34 \pm 0.06	14.59 \pm 0.07
84	15.35 \pm 0.07	14.72 \pm 0.30	14.01 \pm 0.07	14.45 \pm 0.15	14.45 \pm 0.15	14.06 \pm 0.18	13.82 \pm 0.29	15.24 \pm 0.05	15.66 \pm 0.07
85	16.03 \pm 0.00	15.88 \pm 0.01	13.78 \pm 0.07	14.36 \pm 0.03	14.41 \pm 0.04	14.25 \pm 0.05	14.13 \pm 0.03	14.61 \pm 0.06	14.90 \pm 0.07
86	16.09 \pm 0.00	15.94 \pm 0.00	13.75 \pm 0.07	14.38 \pm 0.02	14.55 \pm 0.03	14.20 \pm 0.06	14.09 \pm 0.04	14.08 \pm 0.09	14.08 \pm 0.09
87	15.43 \pm 0.00	15.31 \pm 0.01	12.99 \pm 0.07	13.53 \pm 0.10	13.50 \pm 0.12	13.29 \pm 0.16	13.38 \pm 0.08	13.69 \pm 0.15	14.26 \pm 0.07
88	15.33 \pm 0.01	15.19 \pm 0.01	13.11 \pm 0.07	13.54 \pm 0.06	13.27 \pm 0.20	13.30 \pm 0.16	13.33 \pm 0.09	14.28 \pm 0.07	14.10 \pm 0.07
89	16.56 \pm 0.00	16.46 \pm 0.00	14.63 \pm 0.07	14.98 \pm 0.07	15.00 \pm 0.07	14.86 \pm 0.06	14.82 \pm 0.05	15.38 \pm 0.06	15.63 \pm 0.07
90	16.01 \pm 0.00	15.85 \pm 0.00	14.41 \pm 0.07	14.91 \pm 0.02	15.00 \pm 0.02	14.82 \pm 0.04	14.75 \pm 0.01	15.37 \pm 0.04	15.63 \pm 0.07
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Table A.1. continued.

ID	F(FUV) log(mJy Hz)	F(NUV) log(mJy Hz)	F(H α) log(mJy Hz)	F(3.4 μ m) log(mJy Hz)	F(3.6 μ m) log(mJy Hz)	F(4.5 μ m) log(mJy Hz)	F(4.6 μ m) log(mJy Hz)	F(5.8 μ m) log(mJy Hz)	F(8.0 μ m) log(mJy Hz)
92	15.50 \pm 0.03	15.45 \pm 0.03	13.45 \pm 0.07	14.09 \pm 0.15	14.08 \pm 0.15	**** \pm ****	13.39 \pm 0.31	14.50 \pm 0.07	14.93 \pm 0.07
93	15.90 \pm 0.01	15.78 \pm 0.02	13.25 \pm 0.07	14.40 \pm 0.10	14.09 \pm 0.15	13.99 \pm 0.15	13.73 \pm 0.21	14.43 \pm 0.09	14.64 \pm 0.09
94	14.30 \pm 0.04	14.52 \pm 0.02	13.01 \pm 0.07	14.42 \pm 0.03	14.33 \pm 0.04	14.14 \pm 0.05	14.14 \pm 0.02	14.43 \pm 0.05	14.60 \pm 0.07
95	15.63 \pm 0.01	15.49 \pm 0.01	13.44 \pm 0.07	13.84 \pm 0.09	13.98 \pm 0.07	13.91 \pm 0.07	13.67 \pm 0.07	14.18 \pm 0.07	14.48 \pm 0.07
96	15.59 \pm 0.01	15.45 \pm 0.01	13.54 \pm 0.07	13.81 \pm 0.15	13.70 \pm 0.22	13.58 \pm 0.16	13.64 \pm 0.10	14.03 \pm 0.14	14.22 \pm 0.11
97	15.91 \pm 0.00	15.81 \pm 0.00	14.23 \pm 0.07	14.95 \pm 0.02	14.81 \pm 0.03	14.69 \pm 0.05	14.67 \pm 0.02	15.22 \pm 0.04	15.46 \pm 0.07
98	17.22 \pm 0.00	17.13 \pm 0.00	15.59 \pm 0.07	15.89 \pm 0.01	15.97 \pm 0.02	15.82 \pm 0.04	15.75 \pm 0.01	16.46 \pm 0.04	16.77 \pm 0.07
99	15.97 \pm 0.00	15.83 \pm 0.00	14.33 \pm 0.07	14.37 \pm 0.03	14.51 \pm 0.04	14.40 \pm 0.06	14.17 \pm 0.04	14.53 \pm 0.08	14.84 \pm 0.07
100	15.35 \pm 0.01	15.20 \pm 0.01	13.29 \pm 0.07	13.50 \pm 0.18	13.84 \pm 0.09	13.58 \pm 0.09	13.63 \pm 0.07	14.79 \pm 0.04	15.10 \pm 0.07
101	15.98 \pm 0.02	15.83 \pm 0.02	13.57 \pm 0.07	13.71 \pm 0.42	13.72 \pm 0.42	**** \pm ****	13.82 \pm 0.15	14.75 \pm 0.06	14.88 \pm 0.10
102	15.02 \pm 0.02	14.88 \pm 0.02	13.41 \pm 0.07	14.39 \pm 0.02	14.43 \pm 0.03	14.22 \pm 0.05	14.13 \pm 0.02	14.64 \pm 0.05	14.99 \pm 0.07
103	15.64 \pm 0.01	15.59 \pm 0.01	13.70 \pm 0.07	14.58 \pm 0.06	14.35 \pm 0.11	14.27 \pm 0.09	14.38 \pm 0.04	14.74 \pm 0.06	15.10 \pm 0.07
104	15.90 \pm 0.01	15.77 \pm 0.01	14.01 \pm 0.07	14.35 \pm 0.04	14.44 \pm 0.04	14.21 \pm 0.05	14.12 \pm 0.03	14.95 \pm 0.05	15.30 \pm 0.07
105	15.29 \pm 0.01	15.18 \pm 0.01	13.33 \pm 0.07	13.41 \pm 0.15	13.45 \pm 0.16	13.43 \pm 0.15	13.32 \pm 0.15	13.82 \pm 0.15	14.28 \pm 0.07
106	15.89 \pm 0.01	15.78 \pm 0.01	14.14 \pm 0.07	14.63 \pm 0.03	14.70 \pm 0.03	14.47 \pm 0.05	14.41 \pm 0.02	15.21 \pm 0.04	15.51 \pm 0.07
107	15.62 \pm 0.01	15.49 \pm 0.01	13.38 \pm 0.07	14.35 \pm 0.03	14.42 \pm 0.04	14.23 \pm 0.06	14.01 \pm 0.05	14.15 \pm 0.13	14.08 \pm 0.09
108	15.44 \pm 0.01	15.34 \pm 0.01	13.16 \pm 0.07	14.09 \pm 0.04	14.05 \pm 0.07	13.71 \pm 0.09	13.61 \pm 0.08	13.97 \pm 0.15	13.86 \pm 0.13
109	14.97 \pm 0.01	14.71 \pm 0.02	13.53 \pm 0.07	14.02 \pm 0.03	14.15 \pm 0.03	13.97 \pm 0.05	13.92 \pm 0.02	14.62 \pm 0.05	14.96 \pm 0.07
110	15.81 \pm 0.01	15.62 \pm 0.01	13.54 \pm 0.07	14.23 \pm 0.03	14.23 \pm 0.05	14.04 \pm 0.09	13.95 \pm 0.07	14.25 \pm 0.15	14.05 \pm 0.11
111	15.71 \pm 0.00	15.59 \pm 0.00	13.72 \pm 0.07	13.97 \pm 0.05	14.04 \pm 0.05	14.00 \pm 0.05	14.03 \pm 0.02	14.68 \pm 0.05	14.91 \pm 0.07
112	15.67 \pm 0.01	15.53 \pm 0.01	12.95 \pm 0.07	14.23 \pm 0.02	14.21 \pm 0.03	14.07 \pm 0.05	14.01 \pm 0.03	13.82 \pm 0.15	13.83 \pm 0.09
113	15.43 \pm 0.00	15.31 \pm 0.01	13.48 \pm 0.07	14.19 \pm 0.03	14.03 \pm 0.05	13.92 \pm 0.06	13.99 \pm 0.02	14.23 \pm 0.06	14.54 \pm 0.07
114	14.52 \pm 0.02	14.39 \pm 0.02	12.19 \pm 0.07	**** \pm ****	**** \pm ****	13.14 \pm 0.15	**** \pm ****	**** \pm ****	13.28 \pm 0.16
115	14.88 \pm 0.01	14.68 \pm 0.03	13.16 \pm 0.07	**** \pm ****	**** \pm ****	13.38 \pm 0.15	13.23 \pm 0.15	14.06 \pm 0.09	14.01 \pm 0.08
116	15.24 \pm 0.01	15.13 \pm 0.01	13.19 \pm 0.07	14.02 \pm 0.03	14.04 \pm 0.05	13.76 \pm 0.07	13.78 \pm 0.04	13.74 \pm 0.15	13.88 \pm 0.08
117	16.09 \pm 0.00	15.92 \pm 0.01	14.07 \pm 0.07	14.25 \pm 0.04	14.28 \pm 0.06	14.37 \pm 0.05	14.19 \pm 0.03	14.76 \pm 0.05	14.85 \pm 0.07
118	15.53 \pm 0.01	15.43 \pm 0.01	13.62 \pm 0.07	14.31 \pm 0.02	14.19 \pm 0.04	14.02 \pm 0.05	13.83 \pm 0.03	14.15 \pm 0.06	14.28 \pm 0.07
119	14.73 \pm 0.02	14.56 \pm 0.04	13.07 \pm 0.07	14.48 \pm 0.02	13.20 \pm 0.33	13.77 \pm 0.07	14.13 \pm 0.03	**** \pm ****	**** \pm ****

Table A.2. Logarithmic of the fluxes from $W4$ 12 μm to LABOCA 870 μm bands of our set of H II regions in mJy Hz obtained with centres and apertures given in Table B.1 in Paper I. All the fluxes have been background subtracted. The errors include the uncertainties in the calibration and background subtraction. We did not take into account negative fluxes higher than the corresponding errors, in these cases the fluxes are represented by *****.

ID	F(12 μm) log(mJy Hz)	F(22 μm) log(mJy Hz)	F(24 μm) log(mJy Hz)	F(70 μm) log(mJy Hz)	F(70 μm (pacs)) log(mJy Hz)	F(100 μm) log(mJy Hz)	F(160 μm) log(mJy Hz)	F(250 μm) log(mJy Hz)	F(870 μm) log(mJy)
1	14.77 \pm 0.02	14.83 \pm 0.03	14.88 \pm 0.02	15.67 \pm 0.02	15.74 \pm 0.02	15.88 \pm 0.02	15.74 \pm 0.02	15.35 \pm 0.07	***** \pm *****
2	14.64 \pm 0.02	14.40 \pm 0.03	14.45 \pm 0.03	15.11 \pm 0.02	14.83 \pm 0.04	15.18 \pm 0.04	15.27 \pm 0.03	15.01 \pm 0.07	13.25 \pm 0.09
3	14.47 \pm 0.03	14.56 \pm 0.03	14.55 \pm 0.03	15.26 \pm 0.02	15.32 \pm 0.02	15.64 \pm 0.02	15.41 \pm 0.02	15.04 \pm 0.07	13.14 \pm 0.11
4	14.38 \pm 0.03	14.03 \pm 0.05	13.80 \pm 0.15	15.04 \pm 0.03	15.29 \pm 0.03	15.33 \pm 0.05	15.30 \pm 0.03	14.89 \pm 0.07	***** \pm *****
5	14.56 \pm 0.02	14.54 \pm 0.03	14.57 \pm 0.02	15.18 \pm 0.03	15.31 \pm 0.02	15.42 \pm 0.03	15.36 \pm 0.03	15.01 \pm 0.07	12.91 \pm 0.12
6	14.73 \pm 0.03	14.49 \pm 0.03	14.41 \pm 0.05	15.34 \pm 0.03	15.42 \pm 0.03	15.46 \pm 0.04	15.37 \pm 0.03	15.16 \pm 0.07	13.26 \pm 0.11
7	14.87 \pm 0.02	15.07 \pm 0.02	15.08 \pm 0.02	15.77 \pm 0.02	15.89 \pm 0.02	15.87 \pm 0.02	15.68 \pm 0.02	15.27 \pm 0.07	13.62 \pm 0.08
8	14.04 \pm 0.03	13.74 \pm 0.05	13.99 \pm 0.04	14.61 \pm 0.03	14.47 \pm 0.08	14.31 \pm 0.17	14.89 \pm 0.03	14.58 \pm 0.07	12.72 \pm 0.18
9	14.01 \pm 0.07	13.92 \pm 0.05	13.94 \pm 0.09	14.54 \pm 0.07	***** \pm *****	14.66 \pm 0.13	15.01 \pm 0.04	14.71 \pm 0.07	12.92 \pm 0.15
10	14.29 \pm 0.04	14.08 \pm 0.04	14.26 \pm 0.03	15.02 \pm 0.03	14.96 \pm 0.04	15.38 \pm 0.03	15.03 \pm 0.04	14.64 \pm 0.07	12.82 \pm 0.14
11	13.20 \pm 0.16	***** \pm *****	13.54 \pm 0.05	13.80 \pm 0.16	13.75 \pm 0.21	14.17 \pm 0.15	14.01 \pm 0.15	14.04 \pm 0.10	***** \pm *****
12	14.19 \pm 0.04	14.13 \pm 0.04	14.16 \pm 0.04	14.88 \pm 0.03	15.14 \pm 0.02	15.01 \pm 0.06	15.09 \pm 0.04	14.66 \pm 0.08	12.97 \pm 0.11
13	14.10 \pm 0.06	14.12 \pm 0.05	13.80 \pm 0.10	14.69 \pm 0.05	15.06 \pm 0.04	15.00 \pm 0.06	14.80 \pm 0.07	14.69 \pm 0.08	***** \pm *****
14	14.43 \pm 0.03	14.13 \pm 0.03	14.21 \pm 0.03	14.93 \pm 0.03	14.87 \pm 0.04	15.17 \pm 0.03	15.22 \pm 0.03	14.88 \pm 0.07	13.43 \pm 0.06
15	14.32 \pm 0.03	14.14 \pm 0.03	14.22 \pm 0.03	14.95 \pm 0.03	14.87 \pm 0.04	14.96 \pm 0.05	15.15 \pm 0.03	14.70 \pm 0.07	13.18 \pm 0.07
16	14.35 \pm 0.02	13.93 \pm 0.04	14.10 \pm 0.04	14.69 \pm 0.03	14.83 \pm 0.04	14.98 \pm 0.07	14.78 \pm 0.04	14.63 \pm 0.07	12.80 \pm 0.13
17	14.87 \pm 0.04	14.93 \pm 0.03	14.94 \pm 0.02	15.64 \pm 0.03	15.77 \pm 0.03	15.93 \pm 0.03	15.78 \pm 0.03	15.36 \pm 0.07	13.62 \pm 0.06
18	14.36 \pm 0.02	14.34 \pm 0.03	14.44 \pm 0.03	15.16 \pm 0.02	***** \pm *****	15.38 \pm 0.03	***** \pm *****	14.83 \pm 0.07	***** \pm *****
19	14.40 \pm 0.03	14.34 \pm 0.03	14.41 \pm 0.02	15.02 \pm 0.03	15.06 \pm 0.03	15.23 \pm 0.03	15.21 \pm 0.03	14.76 \pm 0.07	12.77 \pm 0.14
20	15.14 \pm 0.02	15.01 \pm 0.03	14.99 \pm 0.02	15.71 \pm 0.02	15.86 \pm 0.02	16.05 \pm 0.02	15.86 \pm 0.02	15.41 \pm 0.07	13.62 \pm 0.06
21	15.39 \pm 0.02	15.51 \pm 0.02	15.50 \pm 0.02	15.97 \pm 0.02	16.16 \pm 0.02	16.19 \pm 0.02	16.00 \pm 0.02	15.59 \pm 0.07	13.71 \pm 0.06
22	14.98 \pm 0.02	14.98 \pm 0.03	14.97 \pm 0.02	15.70 \pm 0.02	15.84 \pm 0.02	15.92 \pm 0.02	15.77 \pm 0.02	15.36 \pm 0.07	13.40 \pm 0.06
23	15.15 \pm 0.02	15.38 \pm 0.02	15.40 \pm 0.02	15.86 \pm 0.02	16.00 \pm 0.02	16.09 \pm 0.02	15.86 \pm 0.02	15.39 \pm 0.07	13.59 \pm 0.05
24	14.87 \pm 0.02	14.81 \pm 0.02	14.80 \pm 0.02	15.54 \pm 0.02	15.64 \pm 0.02	15.80 \pm 0.02	15.68 \pm 0.02	15.36 \pm 0.07	13.76 \pm 0.05
25	15.08 \pm 0.02	15.26 \pm 0.03	15.28 \pm 0.02	15.79 \pm 0.02	15.91 \pm 0.02	15.98 \pm 0.02	15.78 \pm 0.02	15.33 \pm 0.07	13.20 \pm 0.08
26	14.70 \pm 0.03	14.37 \pm 0.04	14.54 \pm 0.03	15.12 \pm 0.03	15.07 \pm 0.04	15.36 \pm 0.05	15.49 \pm 0.02	15.11 \pm 0.07	13.37 \pm 0.07
27	14.66 \pm 0.02	14.33 \pm 0.06	14.40 \pm 0.04	15.10 \pm 0.04	15.22 \pm 0.04	15.42 \pm 0.04	15.15 \pm 0.06	14.74 \pm 0.10	13.16 \pm 0.07
28	14.88 \pm 0.02	14.96 \pm 0.03	14.95 \pm 0.02	15.73 \pm 0.02	15.86 \pm 0.02	15.82 \pm 0.03	15.67 \pm 0.02	15.32 \pm 0.07	***** \pm *****
29	15.88 \pm 0.02	16.43 \pm 0.02	16.34 \pm 0.02	16.47 \pm 0.02	16.66 \pm 0.02	16.58 \pm 0.02	16.21 \pm 0.02	15.73 \pm 0.07	14.05 \pm 0.06
30	14.96 \pm 0.02	14.93 \pm 0.03	14.95 \pm 0.02	15.68 \pm 0.02	15.76 \pm 0.02	15.95 \pm 0.02	15.79 \pm 0.02	15.42 \pm 0.07	13.72 \pm 0.05
31	14.64 \pm 0.03	14.41 \pm 0.03	14.25 \pm 0.04	15.22 \pm 0.03	15.31 \pm 0.04	15.47 \pm 0.03	15.48 \pm 0.03	15.10 \pm 0.07	13.53 \pm 0.06
32	15.12 \pm 0.02	14.91 \pm 0.03	14.88 \pm 0.02	15.57 \pm 0.02	15.65 \pm 0.02	15.80 \pm 0.02	15.83 \pm 0.02	15.53 \pm 0.07	13.87 \pm 0.05
33	13.90 \pm 0.15	14.03 \pm 0.07	13.97 \pm 0.15	***** \pm *****	14.75 \pm 0.06	***** \pm *****	***** \pm *****	14.47 \pm 0.10	***** \pm *****
34	14.55 \pm 0.04	14.42 \pm 0.04	14.35 \pm 0.04	15.17 \pm 0.03	15.16 \pm 0.02	15.34 \pm 0.05	15.21 \pm 0.04	14.77 \pm 0.08	13.01 \pm 0.07
35	15.01 \pm 0.02	14.96 \pm 0.02	15.02 \pm 0.02	15.44 \pm 0.02	15.56 \pm 0.02	15.72 \pm 0.02	15.62 \pm 0.02	15.22 \pm 0.07	13.56 \pm 0.06
36	13.79 \pm 0.06	13.62 \pm 0.05	13.55 \pm 0.06	14.32 \pm 0.07	14.58 \pm 0.09	14.70 \pm 0.04	14.70 \pm 0.04	14.24 \pm 0.08	12.55 \pm 0.10
37	15.43 \pm 0.02	15.19 \pm 0.03	15.11 \pm 0.02	15.83 \pm 0.02	15.96 \pm 0.02	16.14 \pm 0.02	16.09 \pm 0.02	15.63 \pm 0.07	13.66 \pm 0.06
38	14.01 \pm 0.05	13.08 \pm 0.26	13.97 \pm 0.07	14.74 \pm 0.04	14.26 \pm 0.20	15.01 \pm 0.06	14.94 \pm 0.03	14.53 \pm 0.07	13.20 \pm 0.15
39	13.85 \pm 0.10	13.59 \pm 0.10	14.00 \pm 0.05	14.53 \pm 0.06	***** \pm *****	14.61 \pm 0.15	14.86 \pm 0.04	14.56 \pm 0.07	12.82 \pm 0.10
40	13.80 \pm 0.14	13.94 \pm 0.08	13.96 \pm 0.15	13.77 \pm 0.40	***** \pm *****	***** \pm *****	***** \pm *****	14.65 \pm 0.07	12.59 \pm 0.43
41	15.60 \pm 0.02	15.59 \pm 0.03	15.59 \pm 0.02	16.15 \pm 0.02	16.33 \pm 0.02	16.38 \pm 0.02	16.24 \pm 0.02	15.76 \pm 0.07	13.75 \pm 0.06
42	15.54 \pm 0.02	15.94 \pm 0.02	15.94 \pm 0.02	16.07 \pm 0.02	16.31 \pm 0.02	16.26 \pm 0.02	15.95 \pm 0.03	15.35 \pm 0.07	13.47 \pm 0.06
43	13.48 \pm 0.14	***** \pm *****	13.57 \pm 0.15	13.83 \pm 0.22	14.52 \pm 0.08	14.57 \pm 0.15	14.66 \pm 0.05	***** \pm *****	12.76 \pm 0.24
44	15.91 \pm 0.02	16.25 \pm 0.02	16.26 \pm 0.02	16.55 \pm 0.02	16.79 \pm 0.02	16.79 \pm 0.02	16.48 \pm 0.02	15.90 \pm 0.07	13.94 \pm 0.05
45	14.75 \pm 0.03	14.64 \pm 0.03	14.53 \pm 0.03	15.16 \pm 0.04	15.27 \pm 0.04	15.37 \pm 0.05	15.26 \pm 0.04	14.81 \pm 0.08	12.89 \pm 0.08

Table A.2. continued.

ID	F(12 μ m) log(mJy Hz)	F(22 μ m) log(mJy Hz)	F(24 μ m) log(mJy Hz)	F(70 μ m) log(mJy Hz)	F(70 μ m (pacs)) log(mJy Hz)	F(100 μ m) log(mJy Hz)	F(160 μ m) log(mJy Hz)	F(250 μ m) log(mJy Hz)	F(870 μ m) log(mJy Hz)
46	14.73±0.03	14.45±0.03	14.55±0.03	15.16±0.03	15.31±0.03	15.42±0.04	15.44±0.03	15.03±0.07	13.38±0.06
47	15.03±0.03	15.10±0.03	15.17±0.02	15.53±0.03	15.77±0.03	15.82±0.03	15.59±0.03	15.08±0.07	13.11±0.06
48	14.23±0.05	14.20±0.04	14.33±0.06	15.21±0.03	15.23±0.03	15.43±0.04	15.32±0.03	15.05±0.07	13.24±0.15
49	15.09±0.05	15.33±0.03	15.38±0.02	15.58±0.05	15.96±0.03	15.96±0.04	15.79±0.04	15.26±0.07	13.44±0.06
50	14.57±0.03	14.71±0.03	14.73±0.02	15.36±0.02	15.48±0.02	15.61±0.03	15.40±0.03	14.96±0.07	12.91±0.11
51	14.87±0.02	15.06±0.03	14.47±0.03	15.68±0.02	15.79±0.02	15.84±0.02	15.60±0.02	15.14±0.07	12.79±0.15
52	14.91±0.03	14.77±0.03	14.79±0.02	15.44±0.03	15.62±0.03	15.75±0.03	15.54±0.03	15.05±0.07	13.20±0.06
53	15.00±0.05	15.08±0.03	15.18±0.02	15.46±0.05	15.75±0.04	15.80±0.05	15.59±0.05	14.97±0.10	12.81±0.17
54	14.47±0.04	14.48±0.04	14.48±0.04	15.29±0.03	14.92±0.07	15.39±0.05	15.15±0.05	14.64±0.09	12.81±0.16
55	15.34±0.02	15.53±0.02	15.55±0.02	16.04±0.02	16.19±0.02	16.23±0.02	15.99±0.02	15.46±0.07	13.52±0.06
56	14.12±0.06	14.52±0.03	14.54±0.04	15.08±0.03	15.41±0.03	14.83±0.12	15.11±0.03	14.86±0.07	12.92±0.29
57	14.57±0.02	14.57±0.03	14.60±0.02	15.29±0.02	15.35±0.02	15.52±0.02	15.26±0.02	14.91±0.07	13.01±0.08
58	15.68±0.02	15.60±0.03	15.62±0.02	16.09±0.02	16.30±0.02	16.43±0.02	16.19±0.03	15.66±0.07	13.73±0.06
59	14.35±0.04	13.92±0.07	14.21±0.04	14.72±0.05	14.62±0.07	14.97±0.06	15.04±0.04	14.53±0.08	12.82±0.11
60	14.22±0.03	14.08±0.03	14.21±0.03	14.92±0.03	14.87±0.04	15.22±0.03	14.99±0.03	14.68±0.07	12.49±0.15
61	14.19±0.03	14.20±0.03	14.16±0.04	14.83±0.03	14.78±0.04	15.08±0.04	14.97±0.03	14.43±0.08	12.72±0.13
62	14.32±0.03	13.95±0.05	14.14±0.04	14.85±0.03	14.87±0.03	14.03±0.41	15.13±0.03	14.88±0.07	12.69±0.15
63	15.69±0.02	15.51±0.03	15.54±0.02	16.17±0.02	16.41±0.02	16.47±0.03	16.21±0.03	15.59±0.07	13.50±0.06
64	15.20±0.03	15.16±0.03	15.18±0.02	15.77±0.03	15.92±0.03	16.06±0.03	15.82±0.03	15.29±0.07	13.47±0.07
65	14.31±0.15	14.36±0.06	13.96±0.16	15.15±0.05	15.19±0.06	15.10±0.13	15.13±0.09	14.39±0.18	12.83±0.16
66	15.02±0.04	14.76±0.04	14.74±0.03	14.60±0.22	15.20±0.06	15.43±0.07	15.47±0.05	15.11±0.07	13.10±0.08
67	15.19±0.02	15.37±0.03	15.38±0.02	15.85±0.02	16.05±0.02	16.13±0.02	15.87±0.02	15.35±0.07	13.42±0.06
68	14.01±0.03	14.07±0.03	14.03±0.03	14.63±0.03	14.80±0.03	14.64±0.05	14.78±0.03	14.42±0.07	12.66±0.15
69	14.68±0.03	14.42±0.04	14.40±0.04	15.21±0.03	15.26±0.03	14.80±0.15	15.31±0.04	15.08±0.07	13.21±0.10
70	15.07±0.03	14.89±0.03	14.82±0.02	15.57±0.02	15.48±0.03	15.79±0.03	15.73±0.03	15.33±0.07	13.47±0.07
71	15.25±0.03	15.16±0.03	15.17±0.02	15.63±0.03	15.88±0.03	16.02±0.03	15.82±0.03	15.35±0.07	13.36±0.06
72	14.85±0.03	14.57±0.03	14.57±0.03	15.29±0.03	15.34±0.03	15.62±0.03	15.45±0.04	15.06±0.07	13.19±0.06
73	15.21±0.03	15.07±0.03	15.11±0.02	15.81±0.02	15.91±0.02	16.00±0.03	15.94±0.03	15.43±0.07	13.57±0.06
74	15.55±0.02	15.52±0.03	15.52±0.02	16.09±0.02	16.26±0.02	16.39±0.02	16.23±0.02	15.74±0.07	13.82±0.05
75	14.51±0.03	14.28±0.03	14.35±0.03	14.98±0.03	15.11±0.03	15.33±0.03	15.25±0.03	14.86±0.07	12.88±0.08
76	14.72±0.02	14.48±0.03	14.48±0.02	15.12±0.02	15.31±0.02	15.45±0.02	15.43±0.02	15.14±0.07	13.49±0.06
77	13.93±0.29	14.12±0.11	14.21±0.09	14.59±0.16	14.99±0.08	15.30±0.06	15.03±0.09	14.47±0.15	12.72±0.15
78	15.34±0.02	15.14±0.03	15.14±0.02	15.76±0.02	15.86±0.03	16.06±0.03	15.98±0.02	15.52±0.07	13.61±0.06
79	15.34±0.02	15.42±0.03	15.43±0.02	15.99±0.02	16.15±0.02	16.25±0.02	16.00±0.03	15.51±0.07	13.58±0.06
80	14.68±0.04	14.38±0.05	14.46±0.04	14.90±0.06	15.19±0.03	15.47±0.04	15.38±0.04	15.02±0.07	12.61±0.18
81	14.12±0.04	13.97±0.04	13.68±0.14	14.35±0.09	****±****	14.93±0.06	15.04±0.03	14.65±0.07	12.88±0.14
82	14.60±0.03	14.37±0.03	14.36±0.03	15.05±0.03	15.02±0.06	15.23±0.04	15.27±0.03	14.81±0.07	12.75±0.13
83	13.98±0.09	13.84±0.08	14.06±0.10	14.86±0.03	14.69±0.07	****±****	15.23±0.03	14.77±0.07	13.12±0.18
84	14.13±0.03	14.05±0.03	14.16±0.04	14.84±0.03	14.80±0.04	14.84±0.07	15.07±0.03	14.74±0.07	13.15±0.07
85	15.11±0.04	15.23±0.03	15.26±0.02	15.68±0.03	15.97±0.02	16.06±0.03	15.89±0.03	15.44±0.07	13.04±0.10
86	14.43±0.04	14.51±0.03	14.42±0.03	15.00±0.04	15.22±0.03	15.39±0.03	15.20±0.04	14.75±0.08	13.08±0.07
87	13.69±0.15	13.55±0.15	13.93±0.14	14.83±0.03	****±****	15.35±0.04	****±****	14.62±0.07	****±****
88	13.84±0.04	13.53±0.07	13.34±0.19	14.17±0.06	****±****	14.38±0.15	14.81±0.04	14.38±0.07	12.67±0.15
89	****±****	****±****	13.38±0.21	****±****	****±****	14.73±0.09	****±****	14.39±0.07	****±****
90	15.24±0.04	15.46±0.03	15.47±0.02	15.96±0.03	16.12±0.02	16.15±0.03	15.95±0.03	15.43±0.07	13.57±0.06
91	15.29±0.02	15.49±0.02	15.50±0.02	15.78±0.02	15.98±0.02	16.05±0.02	15.88±0.02	15.44±0.07	13.54±0.05

Table A.2. continued.

ID	F(12 μ m) log(mJy Hz)	F(22 μ m) log(mJy Hz)	F(24 μ m) log(mJy Hz)	F(70 μ m) log(mJy Hz)	F(70 μ m (pacs)) log(mJy Hz)	F(100 μ m) log(mJy Hz)	F(160 μ m) log(mJy Hz)	F(250 μ m) log(mJy Hz)	F(870 μ m) log(mJy Hz)
92	14.53 \pm 0.02	13.97 \pm 0.06	14.23 \pm 0.03	14.82 \pm 0.05	14.62 \pm 0.12	15.14 \pm 0.05	14.90 \pm 0.07	14.61 \pm 0.08	12.60 \pm 0.15
93	**** \pm ****	**** \pm ****	**** \pm ****	**** \pm ****	**** \pm ****	14.72 \pm 0.15	**** \pm ****	14.25 \pm 0.12	12.83 \pm 0.15
94	14.11 \pm 0.04	13.91 \pm 0.03	13.83 \pm 0.04	14.42 \pm 0.04	14.12 \pm 0.08	14.53 \pm 0.08	14.52 \pm 0.09	14.29 \pm 0.08	**** \pm ****
95	13.96 \pm 0.05	13.91 \pm 0.05	14.08 \pm 0.03	14.76 \pm 0.03	14.95 \pm 0.03	14.98 \pm 0.05	14.81 \pm 0.04	14.39 \pm 0.08	12.25 \pm 0.24
96	13.68 \pm 0.15	13.39 \pm 0.15	13.47 \pm 0.21	14.44 \pm 0.10	**** \pm ****	15.24 \pm 0.05	14.62 \pm 0.09	14.29 \pm 0.10	12.73 \pm 0.15
97	15.03 \pm 0.02	15.13 \pm 0.02	15.12 \pm 0.02	15.71 \pm 0.02	15.83 \pm 0.02	15.88 \pm 0.02	15.82 \pm 0.02	15.45 \pm 0.07	13.60 \pm 0.06
98	16.43 \pm 0.02	16.76 \pm 0.02	16.74 \pm 0.02	17.09 \pm 0.02	17.29 \pm 0.02	17.28 \pm 0.02	17.01 \pm 0.02	16.47 \pm 0.07	14.53 \pm 0.05
99	14.25 \pm 0.05	14.53 \pm 0.03	14.65 \pm 0.03	15.31 \pm 0.02	15.39 \pm 0.03	15.48 \pm 0.03	15.39 \pm 0.02	14.92 \pm 0.07	12.99 \pm 0.15
100	14.66 \pm 0.02	14.33 \pm 0.03	14.42 \pm 0.02	14.97 \pm 0.03	15.03 \pm 0.03	15.28 \pm 0.03	15.37 \pm 0.02	15.07 \pm 0.07	13.27 \pm 0.06
101	14.24 \pm 0.12	14.07 \pm 0.12	14.01 \pm 0.15	15.03 \pm 0.07	15.07 \pm 0.08	15.22 \pm 0.06	14.52 \pm 0.34	14.43 \pm 0.21	13.21 \pm 0.10
102	14.65 \pm 0.02	14.91 \pm 0.03	14.92 \pm 0.02	15.32 \pm 0.02	15.45 \pm 0.02	15.39 \pm 0.03	15.20 \pm 0.03	14.91 \pm 0.07	13.12 \pm 0.08
103	14.67 \pm 0.03	14.44 \pm 0.03	14.47 \pm 0.05	15.33 \pm 0.02	14.07 \pm 0.33	15.39 \pm 0.04	15.43 \pm 0.03	15.07 \pm 0.07	13.10 \pm 0.15
104	14.80 \pm 0.02	14.71 \pm 0.03	14.80 \pm 0.02	15.41 \pm 0.02	15.57 \pm 0.02	15.70 \pm 0.02	15.64 \pm 0.02	15.20 \pm 0.07	13.34 \pm 0.06
105	14.05 \pm 0.04	13.93 \pm 0.04	14.06 \pm 0.05	14.55 \pm 0.03	14.71 \pm 0.06	14.71 \pm 0.08	14.46 \pm 0.07	14.47 \pm 0.07	12.66 \pm 0.15
106	15.07 \pm 0.02	15.10 \pm 0.03	15.14 \pm 0.02	15.70 \pm 0.02	15.83 \pm 0.02	15.97 \pm 0.02	15.79 \pm 0.02	15.37 \pm 0.07	13.50 \pm 0.06
107	13.84 \pm 0.09	13.94 \pm 0.05	13.39 \pm 0.38	14.29 \pm 0.09	14.22 \pm 0.15	**** \pm ****	14.77 \pm 0.05	14.29 \pm 0.09	**** \pm ****
108	13.41 \pm 0.13	13.11 \pm 0.36	13.45 \pm 0.16	**** \pm ****	14.02 \pm 0.20	14.60 \pm 0.12	14.48 \pm 0.12	13.97 \pm 0.13	**** \pm ****
109	14.51 \pm 0.02	14.28 \pm 0.03	14.33 \pm 0.02	14.89 \pm 0.03	14.88 \pm 0.03	15.29 \pm 0.03	15.16 \pm 0.03	14.94 \pm 0.07	**** \pm ****
110	14.12 \pm 0.08	13.68 \pm 0.14	14.02 \pm 0.15	14.79 \pm 0.04	**** \pm ****	**** \pm ****	**** \pm ****	14.61 \pm 0.07	**** \pm ****
111	14.46 \pm 0.02	14.28 \pm 0.03	14.26 \pm 0.03	14.96 \pm 0.02	15.09 \pm 0.03	15.18 \pm 0.03	15.23 \pm 0.02	14.92 \pm 0.07	13.02 \pm 0.10
112	13.31 \pm 0.19	13.49 \pm 0.09	13.54 \pm 0.16	14.16 \pm 0.07	**** \pm ****	14.71 \pm 0.07	**** \pm ****	13.62 \pm 0.18	**** \pm ****
113	14.05 \pm 0.04	13.91 \pm 0.04	13.96 \pm 0.05	14.67 \pm 0.03	14.84 \pm 0.04	14.74 \pm 0.07	14.99 \pm 0.03	14.53 \pm 0.07	12.56 \pm 0.15
114	13.01 \pm 0.15	12.94 \pm 0.14	13.19 \pm 0.15	13.26 \pm 0.34	14.26 \pm 0.07	14.24 \pm 0.11	13.81 \pm 0.15	13.50 \pm 0.13	12.40 \pm 0.15
115	13.35 \pm 0.16	13.47 \pm 0.10	13.26 \pm 0.28	**** \pm ****	14.18 \pm 0.11	14.71 \pm 0.09	14.49 \pm 0.05	14.27 \pm 0.07	12.69 \pm 0.15
116	13.41 \pm 0.12	13.20 \pm 0.15	13.40 \pm 0.18	13.66 \pm 0.18	**** \pm ****	**** \pm ****	14.07 \pm 0.15	13.94 \pm 0.11	12.83 \pm 0.11
117	14.44 \pm 0.03	14.04 \pm 0.05	14.19 \pm 0.05	15.10 \pm 0.03	15.07 \pm 0.04	15.24 \pm 0.04	15.21 \pm 0.03	14.94 \pm 0.07	12.76 \pm 0.17
118	13.72 \pm 0.04	13.44 \pm 0.10	13.77 \pm 0.06	14.62 \pm 0.04	14.51 \pm 0.07	14.93 \pm 0.04	14.63 \pm 0.03	14.32 \pm 0.07	**** \pm ****
119	13.10 \pm 0.27	**** \pm ****	13.55 \pm 0.15	14.47 \pm 0.04	14.64 \pm 0.04	**** \pm ****	13.64 \pm 0.27	13.85 \pm 0.11	**** \pm ****

Appendix B: Comparison of fluxes

In Fig. B.1 we show the comparison of the PACS $100\mu\text{m}$ and $160\mu\text{m}$ obtained here with the ones published in Paper I. The low luminosity regions tend to show higher fluxes than in previous images, which shows that the new images recover the missed flux in the previous ones. The comparison of PACS and MIPS $70\mu\text{m}$ fluxes is shown in the left panels of Fig. B.1. In general PACS $70\mu\text{m}$ fluxes are higher than MIPS $70\mu\text{m}$ ones for bright regions. This trend is the same as it was found in Aniano et al. (2012) for NGC 628 and NGC 6946.

Appendix C: SED fitting for *Desert* dust model

We show here the results of the SED fitting using the classical dust model from Desert et al. (1990). This model does not distinguish between neutral and ionised PAHs and therefore it is not able to fit properly the $6\text{--}9\mu\text{m}$ wavelength range corresponding to ionised PAHs. All the SEDs in Fig. C.1 show high residuals in this wavelength range. However, as we can see from Fig. C.2, *Desert* dust model also predicts a higher Y_{VSG} for *filled* and *mixed* than for shells and clear shells, showing that the destruction of BGs into VSGs by strong shocks is mainly regulated by the size of the grains.

Appendix D: Robustness of the best fit

The SED fitting is obtained based on the Levenberg-Marquardt minimisation method. We have explored the robustness of the fit using the best fit SED given by the minimisation method and creating a new *fake* SED which is then fitted with the same initial parameters. We generate the new fluxes of the *fake* SED in each band choosing a random flux value from a Gaussian distribution having the best fit flux as a mean value and the observational uncertainty as σ . The best fit parameters of the new fit is then compared with those obtained initially. In Fig. D.1 we show the comparison for the parameters in the fit for each H II region. The relative abundance of the grains derived from the fit are quite robust, however the differences in the ISRF scale seem to increase for higher values of F_0 .

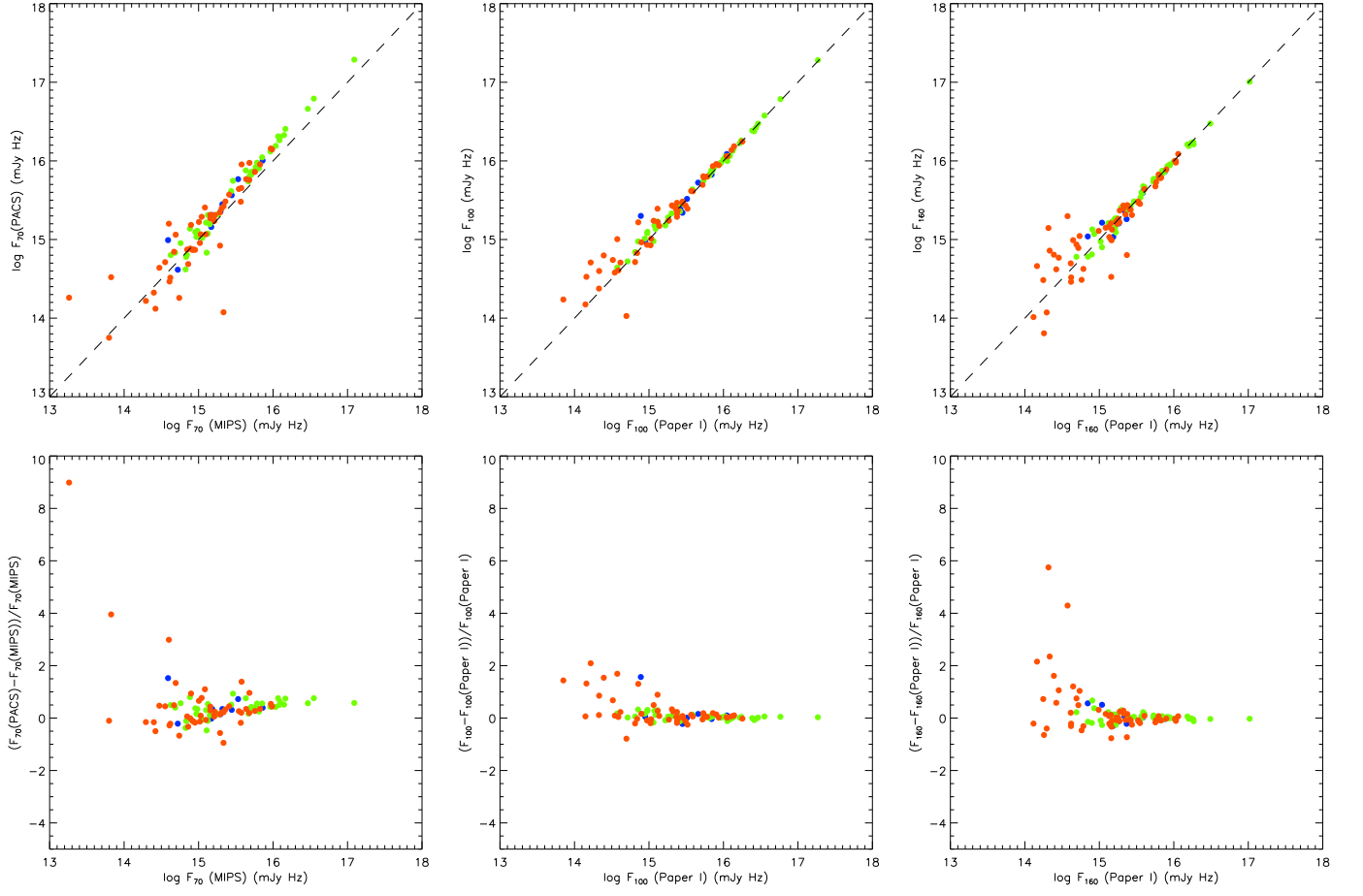


Fig. B.1. Left column: Comparison of the MIPS and PACS $70\mu\text{m}$ fluxes. Middle and right columns: Comparison of the PACS $100\mu\text{m}$ and $160\mu\text{m}$ fluxes presented in this paper and those published in [Paper I](#).

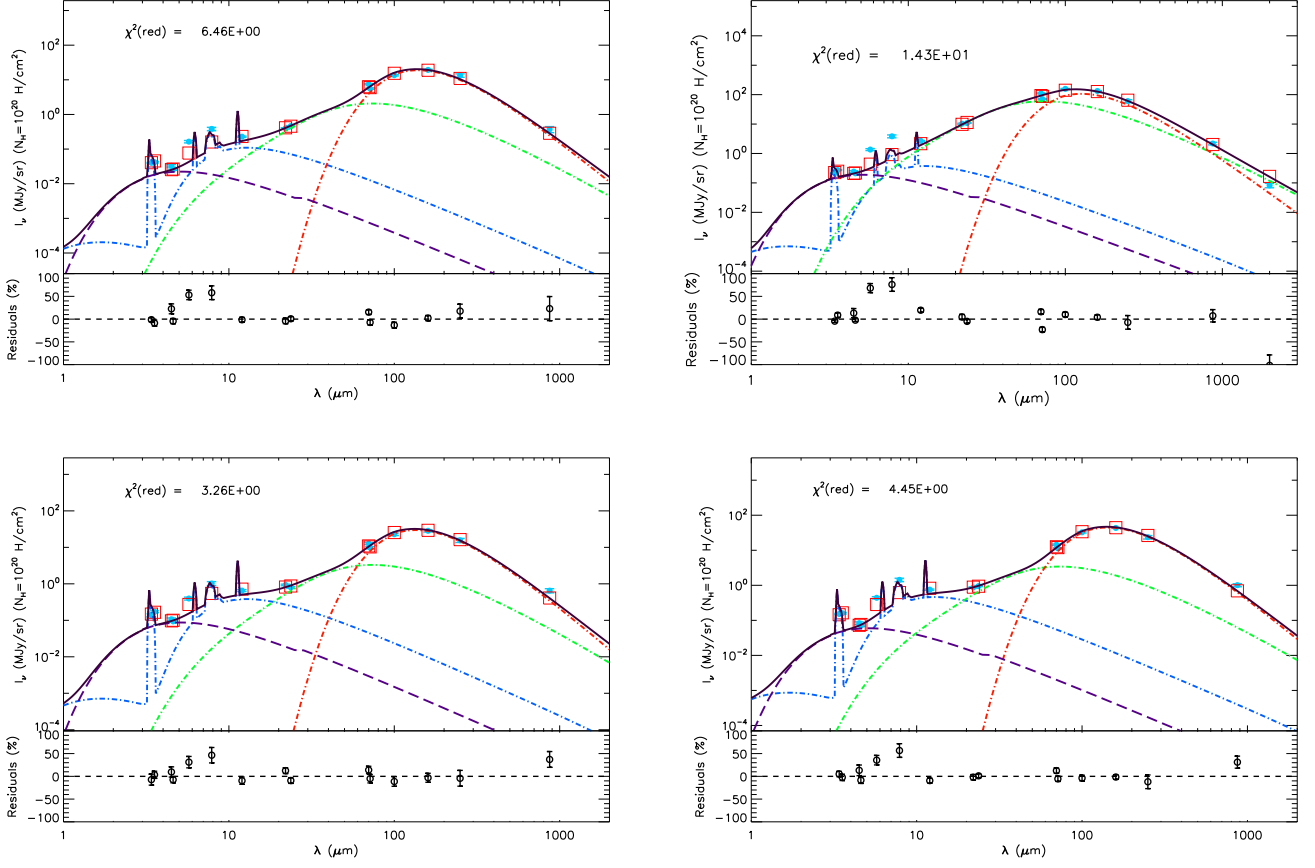


Fig. C.1. SED fittings for the 4 regions shown in Fig. 4 but fitted with a 4 Myr star cluster ISRF and *Desert* dust model. *Light blue points*: observed data with the errors, *red squares*: modelled broad-band fluxes, *dashed-dot blue line*: PAH emission, *dashed-dot green line*: VSG emission, *dashed-dot red line*: BG emission and *dashed purple line*: NIR continuum. The SED is well fitted at most bands except in the 6-9 μm wavelength range where the *Desert* dust model under-predicts the PAH emission.

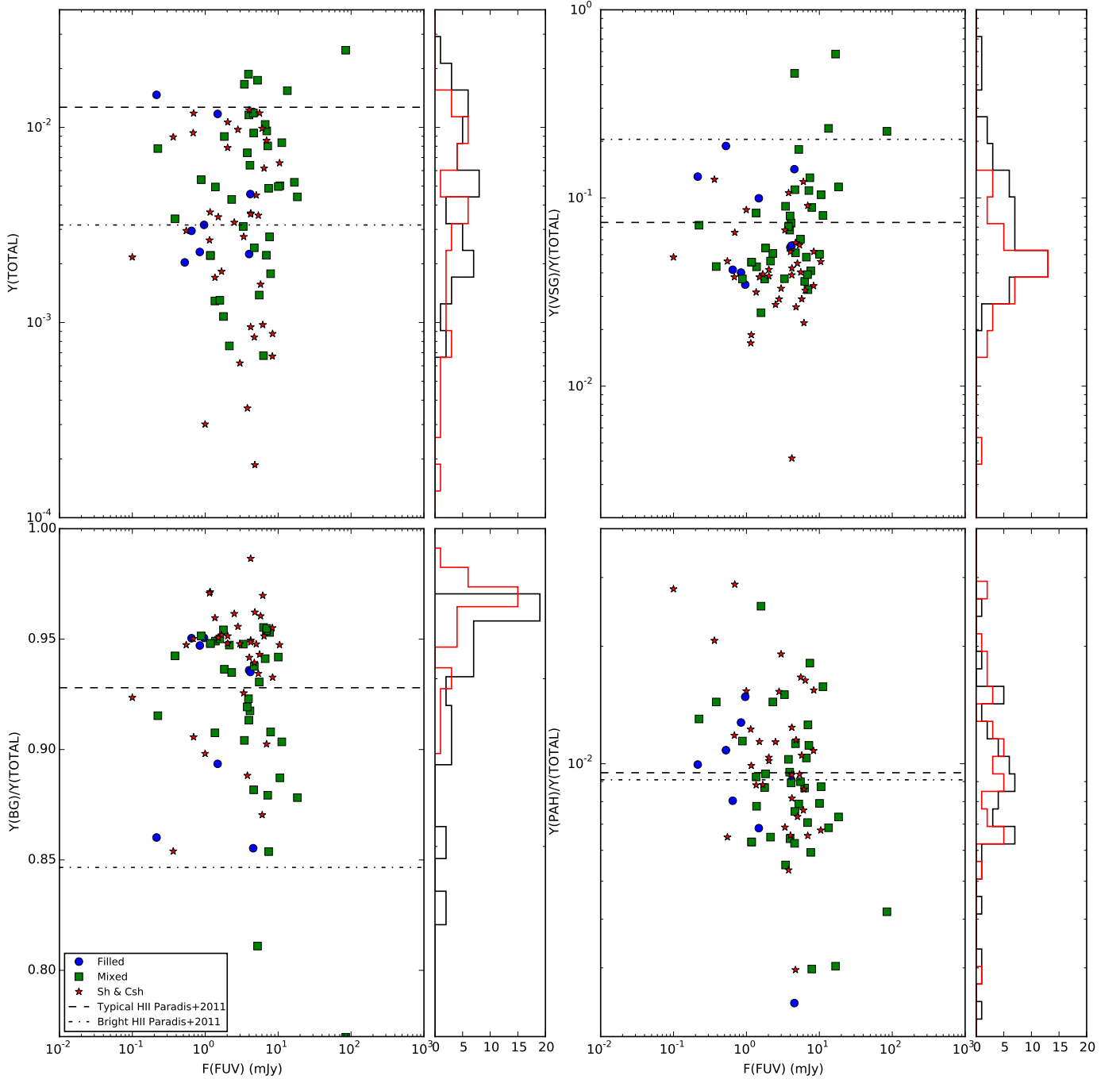


Fig. C.2. Dust mass abundances obtained fitting the SED of each region using 4 Myr ISRF and *Desert* dust model. Only fits with a $\chi^2_{\text{red}} < 20$ are taken into account. The colour code is the same as in Fig 5. *Dot and dashed lines* correspond to the values obtained by Paradis et al. (2011) for *typical* and *bright* H II regions in the LMC modelled assuming a 4 Myr star cluster ISRF and *Desert* dust model.

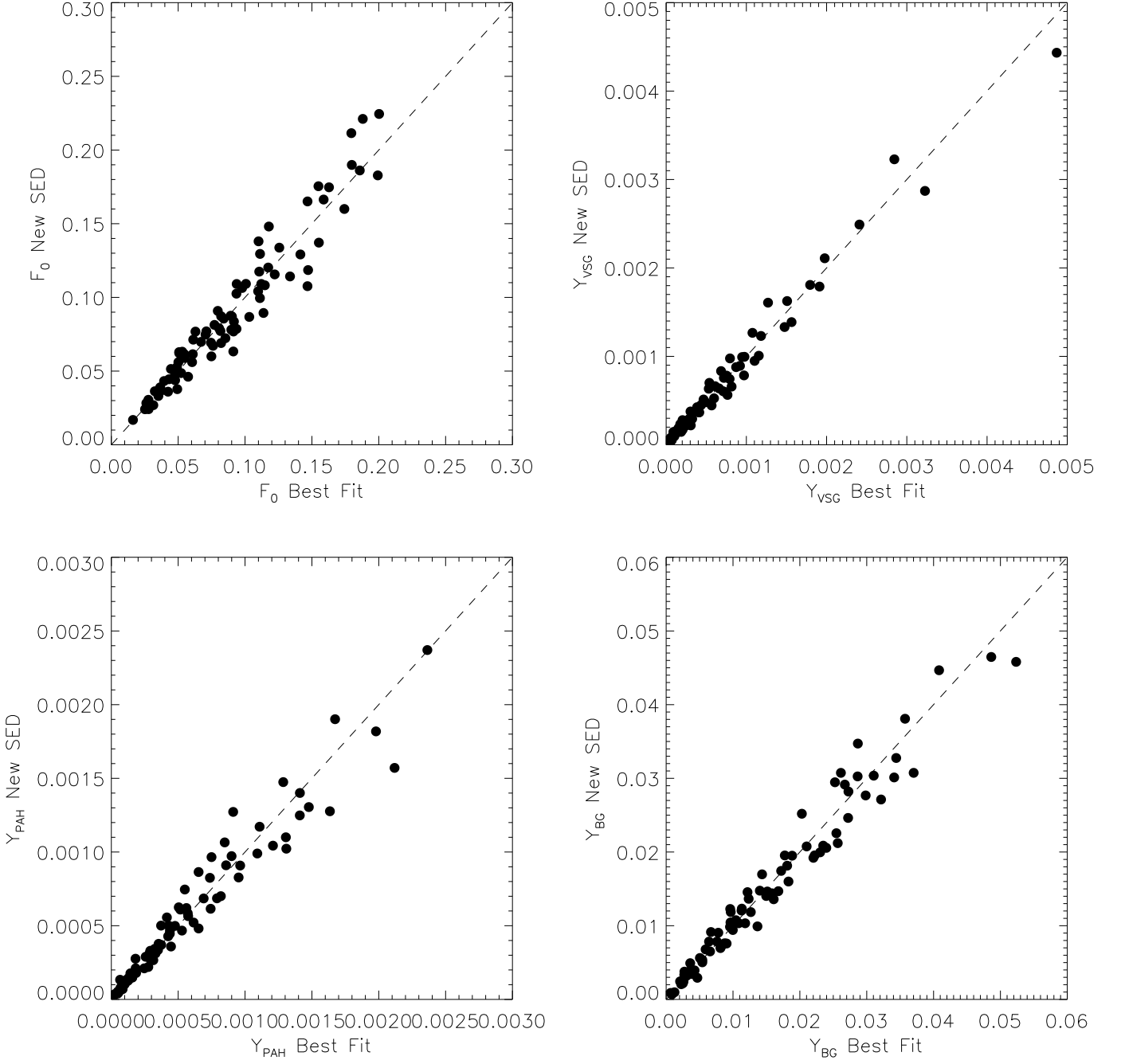


Fig. D.1. Robustness of the best fit for the F_0 (top-left), Y_{VSG} (top-right), Y_{PAH} (bottom-left), and Y_{BG} (bottom-right). We use the best fit SED given by the minimisation method ($Y_{BestFit}$) and create a new SED choosing a random flux value in each band from a Gaussian distribution having the best fit flux as a mean value and the observational uncertainty as σ . The best fit parameters of the new fit (Y_{New}) are then compared with those obtained initially from the minimisation method.